NAPLN-A 2-0

LEVEL II

AD A081831

SCHUYLKILL RIVER BASIN,

TULPEHOCKEN CREEK, PENNSYLVANIA.

BLUE MARSH LAKE,

Bernville Protective Works.

DESIGN MEMORANDUM NUMBER 13,

11 May 75

12 534

Final rept.

BERNVILLE PROTECTIVE WORKS

Approved for public release;
distribution unlimited

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

JAN. 1975

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER COE/NAP/BML/DM/no.13 / 2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Blue Marsh Lake Design Memorandum No. 13 (Bernville Protective Works)	5. TYPE OF REPORT & PERIOD COVERED Final Report
	6. PERFORMING ORG. REPORT NUMBER COE/NAP/BML/DM/no.13
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Corps of Engineers Philadelphia District 2nd & Chestnut Sts. Philadelphia, Pennsylvania 19106	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Same as above	12. REPORT DATE March 1975
	13. NUMBER OF PAGES approx. 250
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Blue Mar

pump stations	man-made ponds/lakes	Blue Marsh Lake,Pa
local protective works	pressure conduits	
dam	embankments	
levee	slopes	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Construction of protective works for the Borough of Bernville is necessary to relive that community of flooding hazards created by the construction of the Blue Marsh Dam and Lake project.

Below elevation 300 at the proposed project site lies a relatively uninhabited low-lying area which serves as an overbank flood plain. Many commercial and private improvements, as well as a utility substation and sewage treatment

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facility, lie above elevation 300. Therfore, elevation 300 was fixed as the upper allowable flooding elevation from project-induces flooding.

Four alternate plans--and several options under each plan--were investigated and priced to determine the most economical way to provide effective flood protection acceptable to local officials / utility owners.

The alternative selected called for diverting both the upper and middle tributaries of the Schuylkill River through culverts to Northkill Creek. This plan substantially reduces the size of the pumping station required. The plan also calls for excavation of the pond area and the anticipated use of part of this excavated material to construct the levee.

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

NAPEN-A

23 SEP 1975

SUBJECT: Blue Marsh Lake Project, Bernville Protective Works, Pump Station - Electrical and Mechanical Calculations

Division Engineer, North Atlantic
ATTN: NADEN-T

1. Reference:

a. DAEN-CWE-B (NAPEN-D, 16 Jan 75), 2nd Ind., 16 May 75, Subject: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works, paragraph 10.

b. NAPEN-A (16 Jan 75), 4th Ind., 20 Jun 75, Subject: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works, paragraph 1.c.(10).

c. NAPEN-A, Subject: Blue Marsh Lake Project Coordination Meeting of 21 Jun 75 Regarding Local Protective Works at Bernville, Pa. - Memo for Record, dated 15 Aug 75, paragraphs 4.b.(4), 4.b.(5), 4.b.(6), and 4.b.(10).

2. Inclosed for your review and comments are the Pump Station - Electrical Calculations and Pump Station - Mechanical Calculations in further response to the above references. Please forward copies to higher authority for concurrent review and approval.

FOR THE DISTRICT ENGINEER:

for WORTH D. PHILLIPS
Chief, Engineering Division

2 Incl (7 copies)
1. Pump Station - Electrical Calculations
2. Pump Station - Mechanical Calculations

NADEN-TH (23 Sep 75)   1st Ind
SUBJECT: Blue Marsh Lake Project, Bernville Protective Works, Pump
         Station - Electrical and Mechanical Calculations

DA, North Atlantic Division, Corps of Engineers, 90 Church Street,
New York, NY 10007   29 September 1975

TO: HQDA (DAEN-CWE-E) Washington, D.C. 20314

The Electrical and Mechanical Calculations for the Pump Station are satisfactory and are forwarded as requested.

FOR THE DIVISION ENGINEER:

2 Incl (dupe)
5 cys ea wd

THOMAS J. BEVACQUA
Acting Chief, Engineering Division

DAEN-CWE-E (23 Sep 75) 2d Ind
SUBJECT: Blue Marsh Lake Project, Bernville Protective Works, Pump Station - Electrical and Mechanical Calculations

DA, Office of the Chief of Engineers, Washington, DC 20314 19 Nov 75

TO: North Atlantic Division, Corps of Engineers, 90 Church Street, New York, NY 10007

The calculations are approved subject to the following comments:

1. Mechanical Calculations

a. Sheet No. 4 The flap valve loss (item 5) in paragraph 2) should be deleted as it is not a part of the system losses in the instant case. Only those losses incurred up stream of the beginning of the down (riverside) leg of the discharge line should be included.

b. Sheet No. 5, Friction losses in the discharge line should be determined using the formula given in paragraph 9c (2) of EM 1110-2-3105.

c. Sheet No. 6, Miter bend losses in the discharge line (2 bends) should be determined using a value of K obtained from the curve ($Re=2x10^4$) on WES Hydraulic Design Chart 228-2/1.

2. Electrical Calculations

a. Sheet No. 1, Par. I The 10kw lighting load shown in this paragraph does not agree with the lighting load tabulated on ENG Form 3924-R.

b. Sheet No. 1, Par. II The use of full voltage starting, as implied, should be coordinated with the utility company.

c. Sheet No. 2, Par. IV The motor short circuit contribution should be four times rated motor full load current. This is in accordance with ANSI C 37.13. The asymetrical value would then be 1.15 times the symetrical value.

d. Sheet No. 4, Par. VI I The use of aluminum conductors should be in conformance with the instructions contained in Guide Specification CE-1404.04.

FOR THE CHIEF OF ENGINEERS:

wd all incl

for [signature]
HOMER B. WILLIS
Chief, Engineering Division
Directorate of Civil Works

NADEN-T (23 Sep 75) 3rd Ind
SUBJECT: Blue Marsh Lake Project, B--nville Protective Works, Pump Station - Electrical and Mechanical Calculations

DA, North Atlantic Division, Corps of Engineers, 90 Church Street, New York, NY 10007 24 November 1975

TO: District Engineer, Philadelphia ATTN:NAPEN-A

Calculations furnished with basic letter are approved subject to the DAEN-CWE-E comments contained in the preceding indorsement.

FOR THE DIVISION ENGINEER:

F R Pagano
F. R. PAGANO
Chief, Engineering Division

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT. CORPS OF ENGINEERS
CUSTOM HOUSE-2 D & CHESTNUT STREETS
PHILADELPHIA. PENNSYLVANIA 19106

23 SEP 1975

IN REPLY REFER TO
NAPEN-A

SUBJECT: Blue Marsh Lake Project, Bernville Protective Works, Pump Station - Electrical and Mechanical Calculations

Division Engineer, North Atlantic
ATTN: NADEN-T

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2. Inclosed for your review and comments are the Pump Station - Electrical Calculations and Pump Station - Mechanical Calculations in further response to the above references. Please forward copies to higher authority for concurrent review and approval.

FOR THE DISTRICT ENGINEER:

2 Incl (7 copies)
1. Pump Station - Electrical Calculations
2. Pump Station - Mechanical Calculations

for G. P. Dilley
WORTH D. PHILLIPS
Chief, Engineering Division

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

NADEN-T (15 Aug 75) 1st Ind
SUBJECT: Blue Marsh Lake Project Coordination Meeting of 21 July 1975
Regarding Local Protective Works at Bernville, PA

DA, North Atlantic Division, Corps of Engineers, 90 Church Street
New York, NY 10007 21 August 1975

TO: HQDA (DAEN-CWE-B) Washington, D.C. 20314

The Memo for Record enclosed with the basic letter is satisfactory to NAD. Your comments and/or concurrence are requested.

FOR THE DIVISION ENGINEER:

1 Incl (quint)
wd 2 cys

THOMAS J. BEVACQUA
Acting Chief, Engineering Division

DAEN-CWE-B (NAPEN-A, 15 Aug 75) 2nd Ind
SUBJECT: Blue Marsh Lake Project Coordination Meeting of 21 July 1975
Regarding Local Protective Works at Bernville, PA

DA, Office of the Chief of Engineers, Washington, D.C. 20314 8 September 1975

TO: Division Engineer, North Atlantic, ATTN: NADEN-T

1. The minutes of the subject meeting are concurred in, subject to the comments in the following paragraphs.

2. The practicability of providing a diversion channel in lieu of #1 dam and conduit should be established.

3. Paragraph 4b(6). The diameter of the vent should be approximately one-fourth that of the pump discharge line. The subject minutes should be changed accordingly.

FOR THE CHIEF OF ENGINEERS:

1 Incl
wd

for HOMER B. WILLIS
Chief, Engineering Division
Directorate of Civil Works

BY KJB DATE 16 Sept 75 SUBJECT Bernville Pumping Plant SHEET NO 1 OF 3
CHKD. BY [illegible] DATE 22 Sept 75 Electrical Calculations JOB NO

I. Connected loads:

Load Description	KW	KVAR
Ventilation fans (2-½ hp)	1.8	1.4
lighting (primarily incandescent)	10	—
Receptacles	2	—
Motor & Controller Heaters	5	
Dehumidifiers (Desicant type)	11	
Dewatering Pump (25hp)	22.8	17.1
Sewage & Drainage Pumps (3-25hp)	68.4	51.3
Storm Water Pumps (6-250hp)	1152.0	864.0
Misc	3.0	3.0
Total	1276.0	936.8

$$KVA = \sqrt{KW^2 + KVAR^2} = 1583\ KVA$$

A 1500 KVA Transformer will be sufficient since actual load on the storm water pumps is less than the 250 hp motor rating (approx. 215 hp at design conditions per pump calculations). Also, all six pumps will rarely operate together, and the dehumidifier will be locked out during pump operation.

II Selection of Voltage for Storm Water Pumps:

A comparison was made between the costs of using a 2300 Volt system for the storm water pumping unit and a 460 volt system. Prices were obtained from Westinghouse on comparible systems for each of the voltages. Only major items of equipment are included in this summary. Installation costs are included.

Item Description	Cost - 2300 V	Cost - 460 Volt
13.2 KV incoming Switch Gear	$41,000	$41,000
1500 KVA Transformer	$20,000	$20,000
Motor Control Center	$64,000	$21,000 *
6-250hp Motors	$61,000	$51,000
Total	$186,000	$133,000

* The 460 Volt Motor Control Center priced in the summary is a Westinghouse type W unit incorporating motor starters protected by "Motor Circuit Protectors". The latter

Incl

are essentially specially design molded case circuit breakers with adjustments to provide special protection for motor circuits. Switchgear using drawout air circuit breakers could be used but would add approximately \$40,000 to overall costs and, therefore, is not recommended. 460 volt equipment has been selected based on the above cost summary.

III Selection of Motor type:

A check on motor prices indicates that induction motors are about \$8000. cheaper per unit than synchronous motors, induction motors will therefore be used.

IV Short Circuit Calculations:

A. 480 Volt system

Utility Co. available MVA = 55 MVA

$$\text{Equivalent Per Unit Reactance (PUX)} = \frac{\text{Base KVA}}{\text{Utility KVA}}$$

Assume base KVA = 10000

$$PUX = 10{,}000 \div 55{,}000 = .18$$

Main transformer is 1500 KVA, 13.2 KV - 480 V
%R = .92 & %X = 5.68

$$PUR\ (\text{or } PUX) = \frac{\%X\ (\text{or } \%R)}{100} \frac{(\text{Base KVA})}{(\text{xfmr KVA})}$$

$$PUR = \frac{.92\ (10{,}000)}{100\ (1500)} = .061$$

$$PUX = \frac{5.68\ (10000)}{100\ (1500)} = .378$$

Total PUX = .378 + .18 = .558
Total PUR = .061

$$PUZ = \sqrt{(PUR)^2 + (PUX)^2} = \sqrt{(.061)^2 + (.558)^2} = .561$$

Short Circuit Symetrical Amps (neglecting motor contribution) = Base KVA ÷ ($\sqrt{3}$ · KV · PUZ)

$$I = \frac{10{,}000}{\sqrt{3}\,(.480)(.561)} = 21{,}440$$

Assymetrical Motor Contribution = 5 x rated motor current.

Total Motor currents = $6\underbrace{(302)}_{250hp} + 4\underbrace{(34)}_{25hp} = 1948$

$$5 \times 1948 = 9740$$

Symetrical Motor Contribution = Assymetrical $\div$ 1.25

$$= \frac{9740}{1.25} = 7792$$

Total Symetrical Short Circ Current =
21,440 + 7,792 = **29232 Amps**

This value necessitates the use of current limiting fuses with the combination motor starter to protect the molded case circuit breakers. These fuses will provide a total interrupting capacity of 100,000 amps which will be adaquate despite any changes the utility co. may make on their system.

B. 208 Volt System -

The 208 volt system will be supplied from a 45 KVA 408-208/120 Volt transformer.

To simplify the calculation we will assume infinite available short circuit current at the transformer primary.

Transformer impedance = 3.4 %
P.U.Z. = 3.4(10,000) $\div$ (100)(45) = 7.55

Short Circuit Symmetrical amps

$$I = \frac{10,000}{\sqrt{3}\,(.208)(7.55)} = 3676 \text{ amps}$$

Motor contribution is negligible since load is primarily lighting & descant dehumidifiers, with some fractional horsepower motors.

V Service Calculations:

Service load = Connected load + 25 % of rating of largest motor.

$$I = \frac{1583 \text{ KVA}}{\sqrt{3}\,(.480)} + \frac{302}{4} = 1980 \text{ amps}$$

This load would require six sets of 500 MCM copper conductors.

2000 Amp bus duct would provide a neater & simpler service & is therefore proposed.

VI Major Branch Circuit Calculations:

1. 250 Hp Storm Water Pumps:
   a. Rated Current = 302 Amps
      Required Branch Circuit Capacity = 1.25 × 302
      = 377.50

   #500 MCM Copper or 2 sets of
   #250 MCM Aluminum will be adaquate.

   b. Voltage drop
      Worst case: 100' (max) run
      to pump at far end of building.

      100' × 302 Amp = 30200 Amp ft
      #500 MCM has voltage drop
      of approx .65 V per 10,000
      A-ft.
      Volt drop = .65 × $\frac{30200}{10000}$ = 1.96 Volts
      1.96/460 = .43 %

2. 25 hp pump Motors

   a. Rated current = 29 amps
      Required Branch Circuit Capacity
      = 1.25 × 29 = 36.25
      #8 Copper is adaquate.

   b. Voltage drop
      Worst case: 75' (max.) run to
      most distant pump.
      75' × 29 amps = 2175 A-ft
      #8 has voltage drop of approx
      12 Volts per 10,000 A-ft.

      Voltage drop = 12 × $\frac{2175}{10000}$ = 2.61 Volts

      $\frac{2.61}{460}$ = .57 %

3. Dehumidifiers (desicant type)

   a Load = 5.5 Kw @ 208 V 3 ϕ
      = 15.3 amps
      #12 Copper is adaquate

   b. Voltage drop
      Worst case: 100' (max) run to furthest unit
      100' × 15.3 Amp = 1530 A-ft

      #12 has voltage drop of approx.

30 volts per 10,000 A-ft

$$\text{Voltage drop} = 30 \times \frac{1530}{10000} = 4.59 \text{ volts}$$

$$\frac{4.59}{208} = 2.2\%$$

VII lighting Calculations:

See attached Eng Form 3924-R for Operating Room & Sump area lighting calculations.

Berrville Pumping Plant ELECTRICAL REQUIREMENTS CALCULATIONS

AREA				DESIGN FOOT-CANDLE	C.U. (1)	M.F. (2)	REQUIRED DESIGN LUMENS	FIXTURE TYPE	LAMPS	ACTUAL (3)	
DESIGNATION	ROOM INDEX	WIDTH	LGTH						NO. WATTS	LUMENS	FOOT-CANDLE
Operating Room	D	24'	66'	30	.7	.8	85,000	I-4P	14-300	84000	29.6
Storm Water Pump Sump	J	8'	35'	2	.1	.8	7,000	VG-2	2-200	7880	2.25

(1) C.U. = Coefficient of utilization (2) M.F. = Maintenance factor (3) Actual foot-candle = Design foot-candle X $\frac{\text{Actual lumens}}{\text{Required lumens}}$

ENG FORM 1 APR 66 3924-R (ER 1110-345-700)

BY ~~AM~~ DATE 6/10/75 SUBJECT **MECHANICAL** SHEET NO. 1 OF 25
CHKD. BY ______ DATE ______ Bernville Local Protection JOB NO. ______
Pump Station

300 CFS Pump Station

Basic Assumptions

1. The 300 cfs pumping capacity will be available at ponding elevation 300, station design point.
2. Single service power, 13.2 kv, will be provided.
3. Pump floor elevation at 308.
4. Pump size will be 50 cfs at design elevation.
5. Pump station will be located inside levee
6. Gravity out fall will be a separate structure.
7. Pumps will have overlevee discharge lines.
8. Siphoning will be eliminated by a vent pipe on top of levee, vent pipe 8" pipe
9. All but one pump will shut off by elevation 295. One pump will pump ponding area to approximately 293.

Incl 2

Pump Sizing Calculations
Summary Sheet

Model Curve	Pump Size	Capacity GPM	HP Max	RPM	Specific Speed	Sub. req.
21A	30" w/ 20" bowl	19870	168	691	8169	6' Lift
21A	30" w/ 24" bowl	26400	236	576	7330	7' Lift
21B	30" w/ 24" bowl	24200	215	576	7216	8' Lift
21C	30" w/ 20" bowl	24000	220	864	10756	7' Head
21C	30" w/ 24" bowl	21200	163	576	6937	11' Lift
→ 21C	30" w/ 22" bowl	22900	185	691	8734	2' Lift
19*	28" w/ 30" elbow	24250	250	691	8611	2' Lift
19*	26" w/ 30" elbow	25300	300	864	10508	5' Head
19**	26" w/ 30" elbow	21800	208	864	10508	6' Head

* 2 stage axial flow pump
** Single stage axial flow pump

Pump selection:
Mixed flow pump 30" elbow with 22" bowl

Typical standard pump on page 25.

BY ____________ DATE ________ SUBJECT MECHANICAL ______________ SHEET NO. 3 ____ OF 25

CHKD. BY ________ DATE ________ Bernville Local Protection ______________ JOB NO. ______________

centrifugal pumps applications

50 cfs

SUMP DIMENSIONS VERSUS FLOW

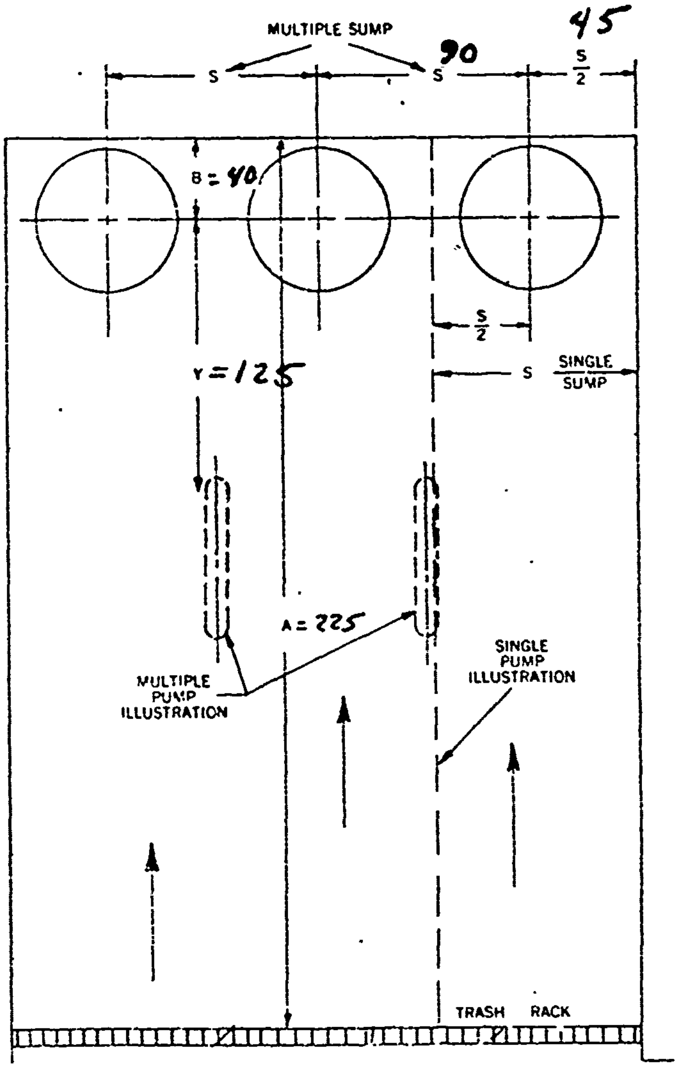


Fig. 65

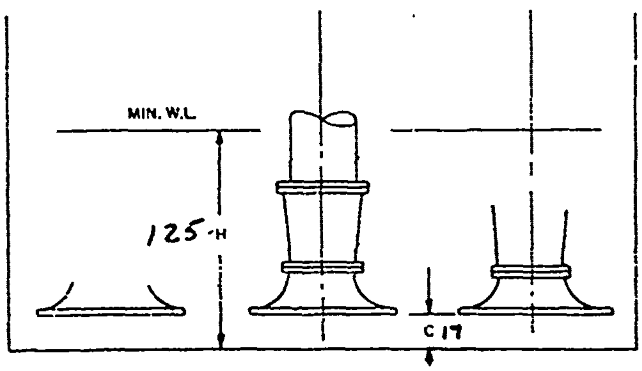


Fig. 66

Condition No 1: Q at maximum ponding elevation
50 cfs or 22,400 gPM at 23 ft static head

Condition No 2: Q_2 at pump starting elevation =
46 cfs or 20,600 gPM at 28 ft static head

1.) D_d = diameter of discharge line

$$D_d = (4 \times Q_1 / 12\pi)^{1/2} \qquad \text{EM 1110-2-3105}$$
$$= (4 \times 50 / 12\pi)^{1/2}$$
$$= 2.3 \text{ ft or } 27.6 \text{ IN}$$

Use 30" O.D. Pipe with 29.25" I.D.

2) Head Losses:

	Q_1 max	Q_1 min	Q_2 max	Q_2 min	Q_3 max	Q_3 min
1. Static head to top of pipe	23.0	23.0	28.0	28.0	32.0	30.0
2. Discharge line Friction	4.35	1.74	3.7	1.48	3.30	1.32
3 Bend Friction	2.96	1.48	2.4	1.20	2.17	1.08
4 Exit Loss	1.85	1.85	1.46	1.46	1.36	1.36
5 Flap Valve Loss	.01	—	.01	—	.01	—
	32.1	28.07	35.57	32.14	36.84	33.76

Condition a) Min - Pressure Flow to top of Levee, Open Channel
Used → Flow from far side of Levee

b) Max Pressure Flow Across Levee No ...

c) ... At Pumping ...

Condition No 3: Q_3 at minimum pum[illegible] = 43 cfs or 19,300 gpm at 30 ft sta[illegible] head.

Discharge line friction 30" pipe with 29.25" I.D.
Velocity correction — 1.0585
Velocity head correction — 1.1208
Head loss /100 ft correction — 1.1492

Pipe I.D.	Q_1	Q_2	Q_3
30" $V =$	9.70 ft/sec	9.26 ft/sec	8.79 ft/sec
$H_v =$	1.65 ft	1.38 ft	1.21 ft
$H_f =$	1.51 ft/100 ft	1.29 ft/100 ft	1.15 ft/100 ft
29.25" $V =$	10.26 ft/sec	9.8 ft/sec	9.30 ft/sec
$H_v =$	1.85 ft	1.46 ft	1.36 ft
$H_f =$	1.74 ft/100 ft.	1.48 ft/100 ft.	1.32 ft/100 ft

Discharge Line Friction

	Q_1	Q_2	Q_3
100 ft of pipe	H_f = 1.74 ft	1.48 ft	1.32 ft
250 ft of pipe	H_f = 4.35 ft	3.70 ft	3.30 ft

100 ft to top of levee
250 ft [illegible] length

Discharge line length: Use average distance to top of levee, 100 ft.

Bend friction: Cameron Hydraulic Data

$$h_e = k\frac{V^2}{2g} \qquad k = .125\left(\frac{45}{90}\right)^2(1.45) = .453$$

* Average value for a mitre welded elbow.

$$h_e = .453\left(\frac{V^2}{2g}\right)$$

@ Q_1 : h_e = .74 ft ; @ Q_2 : h_e = .60 ft ; @ Q_3 : h_e = .54 ft

Flap gate losses: Hydraulic Design Criteria,

$$h_L = k\frac{V^2}{2g} \qquad H_v = V^2/2g$$

Q_1 — H_v = 1.85 ; D/H_v = 1.31 ; k_{Q_1} = .01 ; h_L = .018

Q_2 — H_v = 1.46 ; D/H_v = 1.66 ; k_{Q_2} = .0[illegible] ; h_L = .015

Q_3 — H_v = 1.36 ; D/H_v = 1.79 ; k_{Q_3} = .01 ; h_L = .014

Pump losses : EM 1110-2-3105

Long radius elbow = .25 ($V^2/_h$) = .25(1.85) = .46 ft

Pump column loss : Use 10' column of 30" pipe

$$h_f = .0366\frac{V^{1.8}}{D^{1.17}} = .0366\left(\frac{10.26^{1.83}}{2.5^{1.17}}\right) = .0499\ \text{ft}/100\ \text{ft}$$

for 10 ft h_f = .005 ft

Total pump loss = .465 ft

FLOW THROUGH GATE OPENINGS.

Theoretical Weir (from Eng ...)

$Q = \frac{2}{3} C L \sqrt{2g} h$ $C = .62$

$h = (Q^2/(8C^2 ...))^{1/3}$

@ Q = 50 CFS $h = 1.67$ ft

Critical h to pass 50 CFS through gate opening. USE h = 2 FT

Assuming equal flow through ... pumps

@ Q = 43 CFS, h = 8 FT } h = .43 ft

Minimum ... pump 43 CFS just before pump shut down

Water velocity across ... = 7.17 FPS

Minimum pumping elevation for storm pumps — ELEVATION 293.42

Notch Weir

$Q = 3.33 (L - .2h) h^{3/2}$

@ L = 7, h = 2, Q = ... CFS

Trashrack Losses:

Hydraulic Design Criteria, Chart 010-7

Trashrack bars: 3/8" X 3" ∴ $L/T = 8$

Bar spacing 3" on centers

Use unit height to determine Area ratio

$$A_r = \frac{\text{Area of Bars}}{\text{Area of Section}} = \frac{3/8 \text{ in}^2}{3\ 3/8 \text{ in}^2} = .111$$

$\therefore K_t = .09$

$K_t = \Delta h / \frac{V^2}{2g}$; $\Delta h = K_t V^2/2g$

Use A as projected area on vertical plane.

@ h = 1.67 ft ; 50 cfs through a single bay

$A = 13.36\ ft^2$; $V = 3.75$ ft/sec

$\Delta h = .02$ ft

∴ Total h must be 1.69 ft.

Using 2 ft ok

@ h = .42 ft ; Minimum h to pass 43 cfs through six trashracks to supply one pump. $A = 3.36\ ft^2$ $V = 2.13$ ft/sec

$\Delta h = .006$ ft

@ h = 7 ft. ; 50 cfs at max pond elevation 300

$A = 56\ ft^2$; $V = .89$ ft/sec.

$\Delta h = .001$ ft.

System Curve Data for Bernville Protection Work Using 2[illegible] ft & 28 ft Static Pressure Head With a 30" Pump

Pipe I.D. = 29.25" = 2.437 ft

Gallons per Min	Cubic Feet Per. Sec.	Velocity	Reynolds Number	Friction Factor	Velocity Head
GPM	CFS = .002216 GPM	V = .214 CFS	$R_{ey} = 2.36 \times 10^4 V$	$f = 64/R_{ey}$	$H_v = V^2/2g$
0	0	0	0	∞	0
3000	6.650	1.424	3.362×10^4	19.036×10^{-4}	.031
6000	13.300	2.848	6.724	9.517	.126
8000	17.733	3.798	8.965	7.138	.224
10000	22.1[illegible]	4.747	11.207	5.710	.350
12000	26.600	5.697	13.448	4.758	.504
1400[illegible]	31.633	[illegible]641	15.690	4.078	.686
1600[illegible]	35.4[illegible]6	7.596	17.931	3.569	.8[illegible]7
1800[illegible]	[illegible].770	8.546	20.173	3.172	1.136
[illegible]	44.33	9.496	22.414	2.835	1.401
[illegible]000	48.766	[illegible]445	24.655	2.59[illegible]	[illegible]
24000	53.200	11.395	26.897	2.3[illegible]	[illegible]
26000	57.633	12.344	29.139	2.196	2.36[illegible]
[illegible]000	64.283	13.769	32.501	1.969	2.947
32[illegible]	[illegible]	15.193	35.863	1.784	3.588

$$\text{Velocity} = \frac{4\ \text{cfs}}{\pi (2.437)^2} = .2142\ \text{cfs}$$

$$R_{ey} = \frac{\rho V D}{\mu} = \frac{62.30}{32.16} \times \frac{V}{1} \times \frac{2.437}{1} \times \frac{1}{2 \times 10^{-4}} =$$

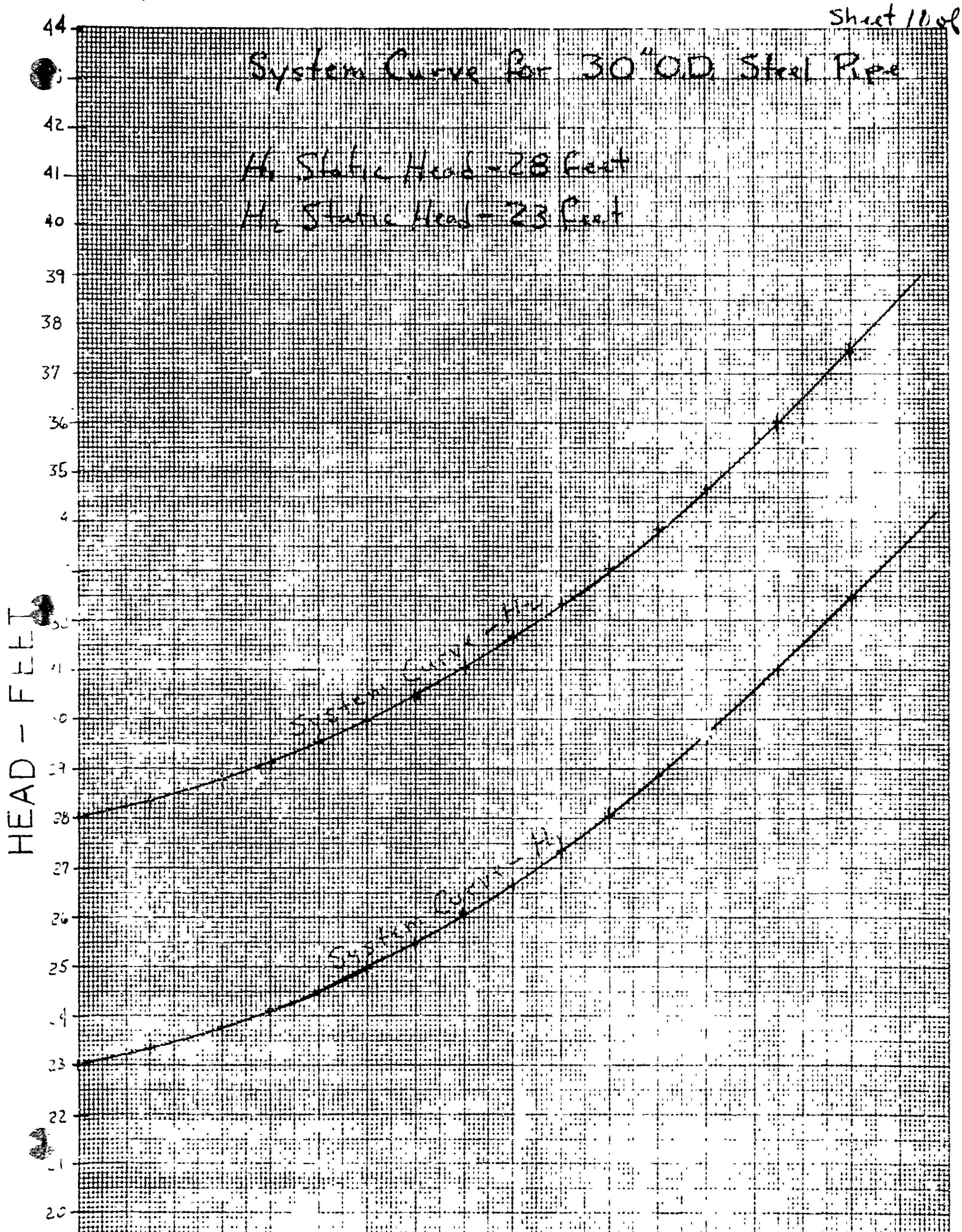
$$= 2.364 \times 10^4 V$$

BY ______ DATE ______ SUBJECT Bernville SHEET NO 10 OF 25

CHKD. BY ______ DATE ______ JOB NO. ______

System Curve 29.25

LOSSES →	DISCHARGE LINE FRICTION @ 100'	EXIT LOSS VELOCITY HEAD	BEND FRICTION $k_E = .453$	TOTAL HEAD	
FORMULA / FLOW	$H_s = f \frac{LV^2}{D2g}$	$H_v = V^2/2g$	$H_c = \frac{.453 V^2}{g}$	$H_T = H_s + H_v + H_E$ + 23	or + 28
0000	0	0	0	23	28
3000	.246	.031	.028	23.305	28.305
6000	.492	.126	.114	23.732	28.732
8000	.656	.224	.203	24.083	29.083
10,000	.820	.350	.317	24.487	29.487
12000	.985	.504	.457	24.946	29.946
14000	1.149	.686	.622	[illegible].457	[illegible]
16000	1.313	.9[illegible]7	.812	26.022	31.022
18000	1.477	1.136	1.028	26.641	31.641
20000	1.642	1.401	1.270	27.313	32.313
22.000	1.806	1.696	1.536	28.038	33.038
24 000	1.970	2.018	1.828	28.[illegible]16	33.[illegible]
26000	2.134	2.369	2.146	29.649	34.649
[illegible]9000	2.381	2.947	2.670	30.998	35.998
3[illegible]000	2.627	3.588	3.251	32.466	37.466


System Curve for 30" O.D. Steel Pipe
H_1 Static Head - 28 Feet
H_2 Static Head - 23 Feet
System Curve - H_1
System Curve - H_2
HEAD - FEET
CAPACITY (x 1000) GPM

BY ____ DATE ____ SUBJECT ____ SHEET NO. 12 OF 25
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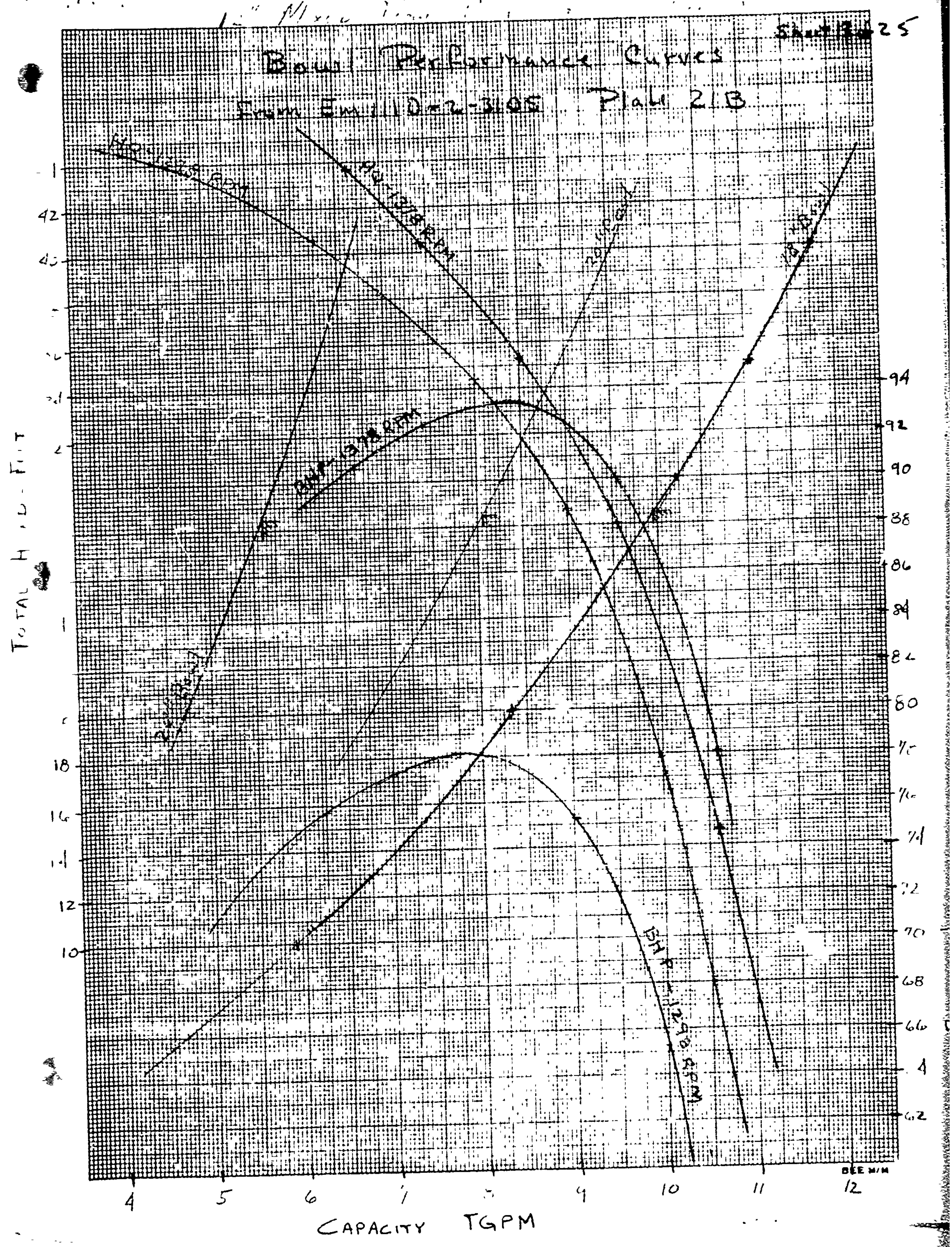
12" Model pump losses - Mixed Flow pump

Use long radius elbow - 16" elbow and Column

Q	V	H_v	$.25 H_v$	$V^{1.83}$	h_e	$.1 h_e$
6250	10.95	1.86	.47	79.82	.11	.011
7000	12.3	2.35	.59	98.75	.14	.014
8000	14.1	3.09	.77	126.79	.18	.018
9000	15.8	3.88	.97	156.15	.22	.022
10000	17.6	4.81	1.20	190.23	.27	.027
11000	19.3	5.78	1.44	225.20	.32	.032

Q	Pump losses	0 Submergence Total bowl head
6250	1.87	38.7 = 40.57
7000	2.36	35.8 = 38.16
8000	3.11	31.3 = 34.41
9000	3.90	24.8 = 28.70
	4.8[illegible]	13.0 = 17.84
[illegible]	5.81	——



Bowl Performance Curves
From Em 10-2-3105 Plate 2B
42
40
18
16
12
10
94
92
90
88
86
80
70
68
62
4
5
6
10
11
12
CAPACITY TGPM

3) Prototype Nozzle Diameter: Plate 21B

$$\frac{D_p}{D_m} = \left(\frac{Q_p}{Q_m}\right)^{1/2}$$

$H_{Tot} = 28.07$ ft.

$Q_m = 7830$ gpm

$D_m = 16''$ mixed flow

$$D_p = D_m \left(\frac{Q_p}{Q_m}\right)^{1/2}$$

$$D_p = 16\left(\frac{22,400}{7830}\right)$$

$D_p = 27.06''$

Nearest standard Size $= 30''$

4.) Model Curve for 18" Bowl prototype

$$Q_m = \frac{Q_p}{(D_p/D_m)^2} = \frac{22,400}{(18/12)^2} = 9,955 \text{ gpm}$$

$$Q_x = Q_c\left(\frac{H_x}{H_c}\right)^{1/2} \qquad \frac{N_x}{N_c} = \frac{Q_x}{Q_c} \qquad N_x = 1233$$

Prototype
Pump curve Condition point for prototype
$Q_1 = 22,400$ gpm; $H_1 = 28.07$ ft.

Bowl performance Curves condition point
$Q_1 = 22,400$ gpm ; $H_1 = 28.5$ ft

Model Condition point Bowl Performance Curves
$Q_m = 9955$ gpm $\quad H_m = 28.5$ ft

$$Q_x = Q_c \left(\frac{H_x}{H_c}\right)^{1/2} = 9955 \left(\frac{H_x}{28.5}\right)^{1/2}$$

H_x	Q_x
40	11794
35	11032
30	10214
25	9324
20	8340
15	7222
10	5897

$$N_c = \frac{N_x Q_c}{Q_x} = \frac{1298\ (9955)}{9380}$$

$N_c = 1378$ rpm

$$Q_c = Q_x \left(\frac{N_c}{N_x}\right) = Q_x\left(\frac{1378}{1298}\right) = 1.06\ Q_x$$

$$H_c = H_x \left(\frac{N_c}{N_x}\right)^2 = H_x \left(\frac{1378}{1298}\right)^2 = 1.13\ H_x$$

$$P_c = P_x \left(\frac{N_c}{N_x}\right)^3 = P_x\left(\frac{1378}{1298}\right)^3 = 1.20\ P_x$$

BY ____________ DATE ________ SUBJECT ________________________________ SHEET NO. 16 OF 25

CHKD. BY ________ DATE ________ JOB NO. ________________

From Bowl Performance Curves - 16" Elbow			Bowl Performance Values $N_e = 1378$		
Q	H	P	Q	H	P
6250	38.7	75.75	6625	43.73	90.63
7000	35.8	77.25	7431	40.45	92.43
8000	31.3	78.0	8493	35.36	93.32
9000	24.8	75.25	9555	28.02	90.03
10000	13.0	65.25	10616	14.69	78.07

5.) Prototype from Model Law

$$Q_p = Q_m \left(\frac{D_p}{D_m}\right)^2 = Q_m \left(\frac{18}{12}\right)^2 = 2.25\, Q_m$$

$$P_p = P_m \left(\frac{D_p}{D_m}\right)^2 = P_m \left(\frac{18}{12}\right)^2 = 2.25\, P_m$$

H_p	Q_p	P_p
43.73	14 [illegible]9	203.92
40.45	16720	207..97
35.36	19109	209.97
28.02	21499	202.57
14.69	23886	175.66

$$N_p = 12/18\,(1378) = 918 \text{ rpm}$$

$$N_s = \frac{918\sqrt{Q}}{H^{.75}} = 11{,}138 \ @\ Q_1$$

STEP #6 CORRECTION FOR SYNCHRONOUS SPEED

STEP DOWN 900 RPM
.96 SLIP FACTOR
864 RPM

CALCULATE HEAD CAPACITY & BRAKE HORSEPOWER

$Q_x = Q_c\,(864/918) = .941\ Q_c$
$H_x = H_c\,(.941)^2 = .885\ H_c$
$P_x = P_c\,(.941)^3 = .883\ P_x$

H_x	Q_x	P_x
38.74	14051	170.0
35.83	15737	173.4
31.32	17985	175.1
24.82	20234	165.9
13.01	22480	146.5

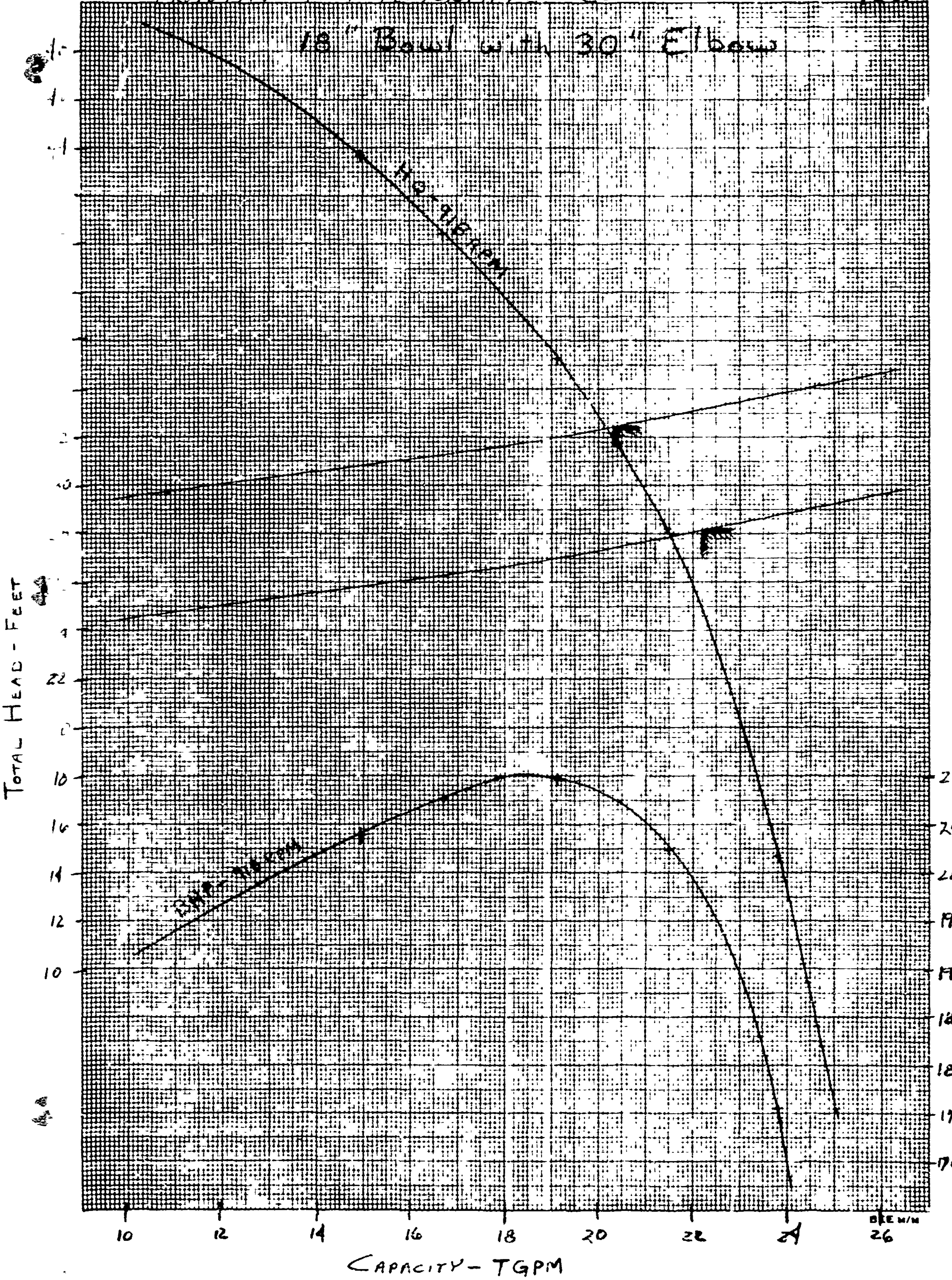
STEP UP 1200 RPM
.96 SLIP FACTOR
1152 RPM

CALCULATE HEAD CAPACITY & BRAKE HORSEPOWER

$Q_x = Q_c\,(1152/918) = 1.26\ Q_c$
$H_x = H_c\,(1.26)^2 = 1.57\ H_c$
$P_x = P_c\,(1.26)^3 = 1.98\ P_c$

H_x	Q_x	P_x
68.87	18734	403.0
63.70	20782	411.0
55.68	23780	414.9
44.12	26979	400.3
23.13	29975	347.1

PROTOTYPE PUMP PERFORMANCE CURVE



4.1) Model Curve for 20" Bowl Prototype

$Q_m = 8064$

Model Condition point Bowl Performance Curve

$Q_m = 8064$ gpm, $H_m = 28.5$ ft

$$Q_x = 8064\left(\frac{H_x}{28.5}\right)^{1/2}$$

H_x	Q_x
40	9553
35	8936
30	8273
25	7553
20	6755
15	5850

Model Curve intersection

$H = 31.75$ ft, $Q = 8520$ gpm, $P = 72.0$ HP

$$N_c = \frac{1298(8064)}{8520}$$

$N_c = 1228$ rpm

$$Q_c = \left(\frac{1228}{1298}\right) Q_x = .946\, Q_x$$

$$H_c = \left(\frac{1228}{1298}\right)^2 H_x = .895\, H_x$$

$$P_c = \left(\frac{1228}{1298}\right)^3 P_x = .847\, P_x$$

5.1) Prototype from Model Law

$$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = 2.78\ Q_m = 2.63\ Q_x$$

$$H_p = H_m = .895\ H_x$$

$$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = 2.78\ P_m = 2.35\ P_x$$

H_p	Q_p	P_p
34.6	16,438	178.0
32.0	18,410	181.5
28.0	21,040	183.3
22.2	23,670	176.8
11.6	26,300	153.3

$$N_p = \frac{12}{20}(1228) = 737 \text{ rpm}$$

$$N_s = \frac{737\sqrt{22400}}{(28.5)^{.75}} = 8,942 \text{ @ } Q_1, H_1$$

6.1) Synchronous Speed & Correction Induction Mtr.

Step down: no good flow already too low.

Step up: horsepower too great.

BY ______ DATE ______ SUBJECT ______ SHEET NO. 21 OF 25

CHKD. BY ______ DATE ______ JOB NO ______

4.2) Model Curve for 24" Bowl [illegible]

$Q_m = 5600$ gpm

Model Curve for [illegible] 1

Q_m 5600 H_m 28.5 ft

$Q_x = 5600 \left(\frac{H_x}{28.5} \right)^{1/2}$

H_x	Q_x
40	6634
[illegible]	[illegible]
20	[illegible]

Model Curve Intersection

$H = 3$[illegible], $Q = 6600$ gpm, $P = 76.$[illegible]

$N_c = \frac{1298(5600)}{6600}$

$N_c = 1101$ rpm

$Q_c = \left(\frac{1101}{1298} \right) Q_r = .8$[illegible] $\times Q_r$

[illegible] $= .720\ H_r$

[illegible] $P_c = .61\ P_r$

5.2) Prototype From Model Curve

$$Q_p = Q_m \left(\frac{D_p}{D_m}\right)^2 = 4 Q_m = 3.392\ Q_x$$

$$H_p = H_m = .720\ H_x$$

$$P_p = 4\ P_m = 2.444\ P_x$$

H_p	Q_p	P_p
27.8	21200	185.1
25.8	23,744	188.8
22.5	27,136	190.6
17.9	30 528	183.9

$$N_p = (12/24)\ 1101 = 550.5$$

$$N_s = \frac{550.5 \sqrt{21200}}{(27.8)^{.75}} = 6620$$

6.1) Synchronous Speed & Induction Motor Correction

Synchronous speed 600 rpm

Induction motor speed = .96 (600) = 576
for 4% slip

$$Q_x = \frac{576}{550.6} Q_c = 1.046\, Q_c$$

$$H_x = \left(\frac{576}{550.6}\right)^2 H_c = 1.094\, H_c$$

$$P_x = \left(\frac{576}{550.6}\right)^3 P_c = 1.145\, P_c$$

Performance at 576 Rpm

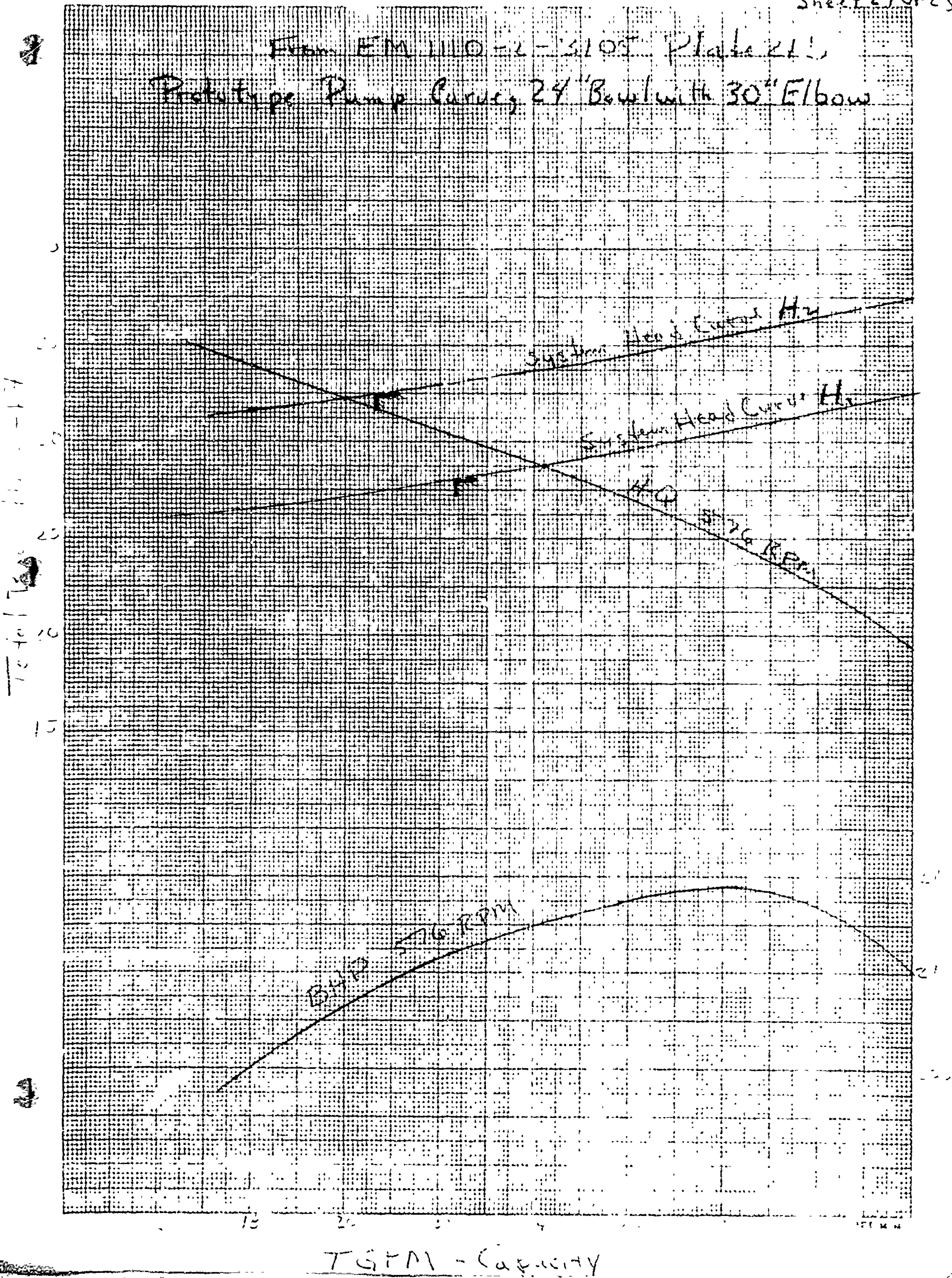
H	Q	P
30.41	22,175	211.94
28.22	24,836	216.18
24.62	28,384	218.24
19.58	31,932	210.57
34.18	17,740	198.96

$$N_s = \frac{\text{Rpm}\sqrt{Q}}{H^{.75}} = \frac{576\sqrt{24200}}{(28.75)^{.75}}$$

$N_s = 7216$

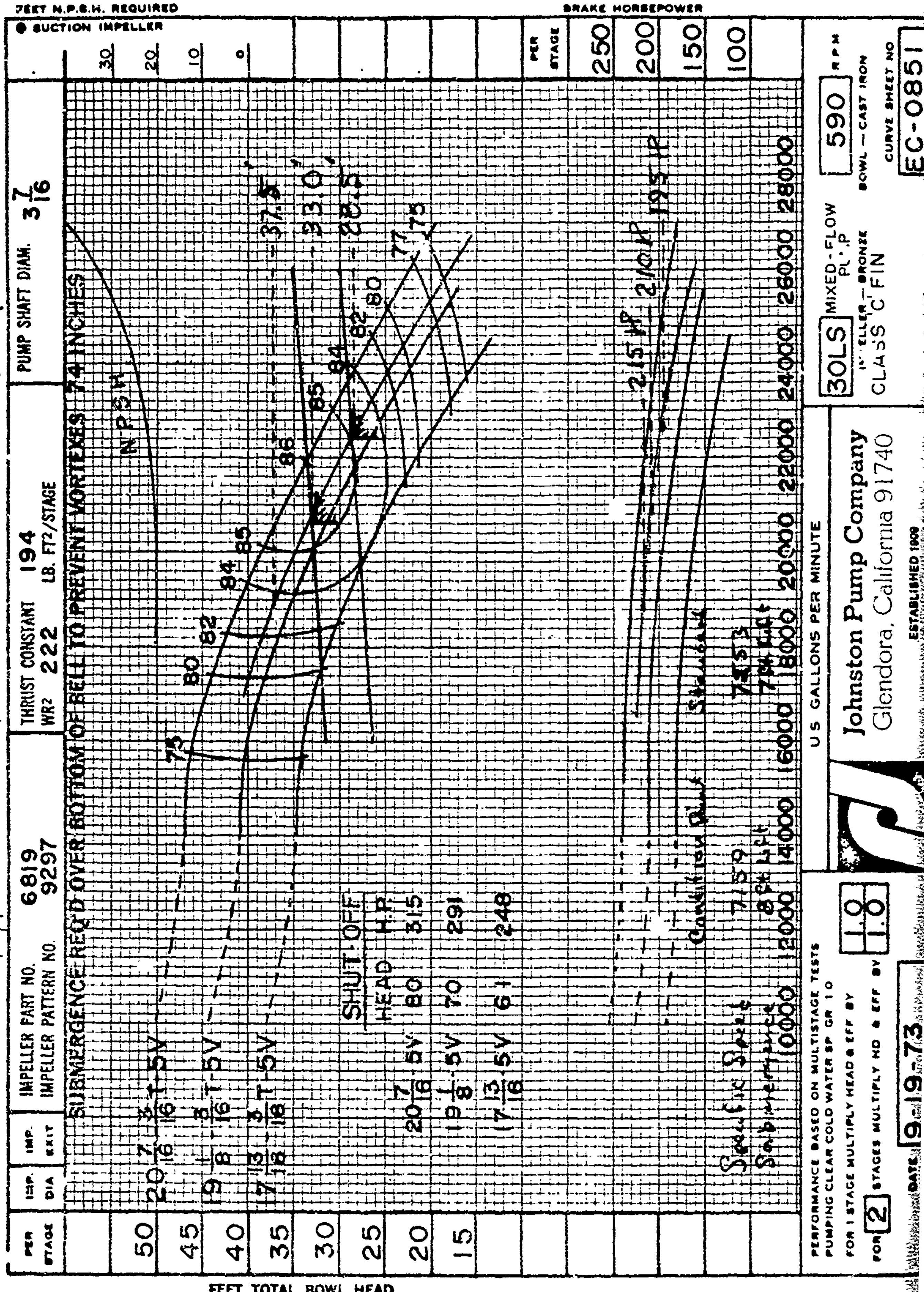
Submergence from EM 1110-2-3102, Plate 16

8 ft suction lift


From EM 1110-2-3105 Plate 21
Prototype Pump Curve, 24" Bowl with 30" Elbow
System Head Curve H4
System Head Curve H1
H-Q
576 RPM
BHP 576 RPM
15
20
25
TGPM - Capacity

Vj 2506-2

Typical Manufacturers Standard Pump



NADEN-TH(15 Aug 75)   3rd Ind
SUBJECT: Blue Marsh Lake Project Coordination Meeting of 21 July 1975
Regarding Local Protective Works at Bernville, PA

DA, North Atlantic Division, Corps of Engineers, 90 Church Street,
New York, NY 10007   16 September 1975

TO: District Engineer, Philadelphia ATTN: NAPEN-A

Forwarded to denote concurrence in the minutes of the subject meeting as contained in the 15 August 1975 Memo for the Record, subject to the comments contained in the 2nd Indorsement.

FOR THE DIVISION ENGINEER:

P.R. Fiscina
for THOMAS J. BEVACQUA
Acting Chief, Engineering Division

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO

NAPEN-A 15 AUG 1975

SUBJECT: Blue Marsh Lake Project Coordination Meeting of 21 July 1975
Regarding Local Protective Works at Bernville, PA

Division Engineer, North Atlantic
ATTN: NADEN-T

Inclosed for your review and comments is the Memo for Record, dated 15 August 1975, of the subject meeting. Please forward to higher authority for concurrent review and approval.

FOR THE ACTING DISTRICT ENGINEER:

Worth D. Phillips

1 Incl
Memo for Record (7 cys)

WORTH D. PHILLIPS
Chief, Engineering Division

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NAPEN-A	Blue Marsh Lake Project Coordination Meeting of 21 Jul 75 Regarding Local Protective Works at Bernville, PA

TO	FROM	DATE	CMT 1
Memo for Record	Ch., Proj Mgmt Br.	15 Aug 75 PRICE/db/7537	

1. In order to assure that the design effort for the subject local protective works may proceed in a timely fashion, a coordination meeting was held in the Philadelphia District office on 21 Jul 75. The following personnel attended.

Vernon K. Hagen	DAEN-CWE-Y
S. H. Miles	DAEN-CWE-D
S. B. Powell	DAEN-CWE-H
J. S. Robertson	DAEN-CWE-E
E. J. Fleming, Jr.	NADEN-TH
E. J. Lally	NADEN-TH
W. D. Stockman	NADEN-T
F. Braun (part-time)	NAPEN-D
Vincent L. Calvarese	NAPEN-D
G. S. Dilley	NAPEN
D. K. Erickson	NAPEN-H
M. Gross (part-time)	NAPEN-D
T. B. Heverin	NAPEN-D
L. J. Lipski	NAPEN-H
Worth D. Phillips	NAPEN
Daniel E. Price	NAPEN-A
F. W. Vinci	NAPEN-D

2. The meeting opened with a discussion of the criteria on which the planning and design concepts for the local protective works are based. It was the consensus of all concerned that it is necessary and proper to provide protection for Bernville and that the degree of protection that would be provided by the levee and pumping station as designed is appropriate. However, there were some questions raised about the design of some of the features of the protective works.

3. The questions and pertinent discussions covered during the meeting are given in this and in the subsequent paragraphs.

a. The District indicated that the natural SDF (assumed by doubling the SPF hydrograph) levels due to Northkill flooding of the lower reaches of Tributaries #1 and #2 were, respectively, 319.7 and 317.2 ft. SLD. With the project in place, the SDF on the Northkill would overtop the levee. The levee would have to be 5 to 6 feet higher to prevent SDF flooding from the Northkill. In regard to the SDF developed for tributaries 1 and 2 by doubling the standard project storm values, it was suggested that maximum precipitation for this flood be compared with that of the maximum probable rainfall which is usually used to develop the spillway design flood.

DA FORM 1 FEB 62 2496 REPLACES DD FORM 96, EXISTING SUPPLIES OF WHICH WILL BE ISSUED AND USED UNTIL 1 FEB 63 UNLESS SOONER EXHAUSTED. ☆ U.S. GPO: 1974-558-130/8656

b. The District indicated that in the event of possible pump malfunction or loss of power, the gravity outlets as designed will pass flows up to the 100 year frequency during local storms when the Northkill is low and the interior ponding can be drained by gravity.

c. Assessment was made of the need to provide trash racks on the pressure conduits with the system as designed. Based on the size of the proposed conduits and the nature and use of the surrounding countryside (agricultural land), it is the opinion of Philadelphia District personnel that trash racks should not be provided. However, should it be necessary to modify the present design concept so as to provide drop inlets for the pressure conduits, then trash racks would be provided. (See paragraph 4.a.)

d. Assessment will be made of the need for riprap protection at the outlets for the pumping station, gravity outlet structure and the pressure conduits below the two detention reservoirs. Riprap will be provided as necessary.

4. In addition to the items covered in the preceding paragraph 3, the following items were also discussed.

a. Based on the configuration of the two pressure conduits, concern was expressed regarding the action of entrapped air on the discharge end of the conduit. The St. Mary's lake project, USBR, in northern Colorado, was shown as an example where high velocity flow combined with a hydraulic jump and entrapped air within the conduit caused the lower end of the conduit roof to completely shear off or collapse. The concern was that a similar type problem could occur with the pressure conduits for the Bernville protective works. However, there is a significant difference in the magnitude of the flow velocities and length of conduit between the Bernville protective works and the St. Mary's lake project. Design of the outlet works as drop inlets was offered as a solution to the design problem. Philadelphia District personnel will study the problem to determine the best design for the inlet structures. Preliminary drawings of any conduit design changes will be submitted to higher authority for review and approval with final design changes incorporated in the contract drawings. Stop log slots at both ends of the conduits will be included for maintenance purposes.

b. The design of the pumping plant was discussed. Comments regarding the pumping plant follow.

(1) It was agreed that it is desirable to keep flood waters below elevation 300 in Bernville, Pa. It was also agreed that the system design may be conservative but, based on available data, present knowledge of area, and the magnitude of flood damages that could be incurred, that the present design capacity of 300 cfs is appropriate and warranted.

(2) The change in power supply voltage from 69 Kv to 13.2 Kv was discussed. The use of a 13.2 Kv line is adequate for this distribution system and the power company can provide a reliable and adequate 13.2 Kv power source. A 69 Kv line would be more practical for higher loads.

(3) The restart problem was discussed briefly. It was suggested that a by-pass with return be used in lieu of eddy-current clutches.

(4) Higher authority requested that electrical calculations be included in future design memorandum submittals rather than with submittal of plans and specifications. Philadelphia District will submit the calculations for all equipment as soon as possible.

(5) The size of the motors was discussed briefly. For 50 cfs pumps, the supplier will probably furnish 460 volt electric motors. Consideration could be given to the use of induction type motors. For electric motor design, Guide Specification 2301 will be used. Motor will be sized such that maximum power required by the motor would be 90 percent of the nameplate rating. Philadelphia District will submit electrical calculations as soon as possible to allow as much review time as possible.

(6) The mechanical and electrical calculations that had been furnished previously as supplemental material for DM 13, were discussed. It was recommended that the discharge lines be considered as free vented lines. In calculations, use the line length from the pump center line to the levee center line. Further, it was recommended that the vent size be approximately 25 percent of the area of the pipe line and that the vents have a 180-degree bend and be screened. The vents are to be located on the far side of the levee. Cost savings could be realized through elimination of the concrete chamber. Philadelphia District will check hydraulic gradient from highest stage on creek side to determine height of vent pipe.

(7) The type of pump was discussed. It was concurred in that a 30" discharge mixed flow pump would be appropriate for this project. Such a pump would require a 90" sump. The specifications should, also, permit use of a 2-stage axial flow pump which in some cases would result in cost savings.

(8) The estimated delivery time for pumps and motors was also discussed. Based on information furnished to Philadelphia District by Johnston Pump Company, delivery time for pumps is about 9 months and for electric motors about 50 weeks. District will also contact Peerless Corporation, Allis-Chalmers, Ingersol-Rand and others for delivery information. Higher authority encouraged the District to purchase the pumps and motors by supply contract. Sufficient data is not available at this time to place orders for these items. The contract

for the pumps and motors must include appropriate testing at the plant. The manufacturer will be given the option of model testing or prototype testing with complete performance curves. Acceptance will be on the basis of factory tests which are to be witnessed by the District's engineering staff. If complete performance data from prior tests conducted by the Corps of Engineers are available, the testing requirement may be waived. There will be no performance tests after shipment from factory. Field tests will be limited to those necessary to see that "its turning in the right direction", for maintenance inspections, for check for pump alignment, etc.

(9) Philadelphia District will check on lead time required for switch gear to preclude contract problems.

(10) Philadelphia District will furnish calculated pump curve data showing upper and lower limit of system head curves for maximum-minimum head conditions, horsepower curves and capacity curves. District will include system loss curves in specifications for pump manufacturers.

(11) The criteria that established the sump floor elevation were discussed. It was agreed that the District would check the feasibility of raising the sump floor to approximately elevation 288 or 290. The sump should not be raised so much as to require an increase in pump size. The District should consider the use of a suction umbrella for the pumps.

(12) The length of the pumping station was discussed and it is considered satisfactory.

(13) Concern was expressed over the shape of the approach channel to the pumping station. Higher authority recommends straight approach channels to avoid vortex problems at the entrance gate. The entrance configuration to the pumping station for the Bernville protective works as shown on the drawings was not considered satisfactory. In order to not turn the water before it enters the pumping station, it was agreed that the channel should be excavated to provide a flat bottom for the ponding area entrance to the pump plant. The pump station would not be reoriented.

(14) Flap gates at the end of discharge lines were discussed. It was agreed that the flap gates could be left off of free-vented lines providing the vents are kept clean.

(15) Higher authority suggested that a walkway be provided in the sump area in order to take vibration readings at vital points, witness pump operation and check lights.

SUBJECT: Blue Marsh Lake Project Coordination Meeting of 21 Jul 75 Regarding Local Protective Works at Bernville, PA

(16) With regard to the discharge structure, it was agreed that the District would review the configuration to preclude silting and debris catching characteristics.

(17) It was suggested by higher authority that the embankments covering the discharge lines have a gentle slope to the adjacent embankment sections. The reason for this is, if the levee should ever fail or be overtopped, it would occur somewhere other than at the pump station and minimize damage to the station.

c. The spillways were discussed and the comments were as follows.

(1) It was recommended that the left wall of the spillway for drainage area 2 be curved in lieu of the sharp angular configuration in order to permit a more even flow.

(2) It was suggested by higher authority that riprap (minimum 24-inch thickness) be provided on the right bank of the spillway for drainage area 1 because of its close proximity to the dam embankment and at the base of the left wall of the spillway for drainage area 2 to preclude erosion. It was agreed that riprap will be provided at left wall of spillway for drainage area 2 and when area 1 is uncovered, if riprap is required it will be incorporated in the contract by modification. The need for riprap protection is also discussed in paragraph 3d of this memo.

(3) Concern was raised with regard to the effect of spillway discharge from the probable maximum flood causing damage greater than the natural occurrence behind the levee downstream of drainage areas 1 and 2. It was suggested that gravity outlets be provided to lessen the hazard due to entrapment and storage of water behind the levee during this flood.

d. Concern was expressed that the discharge structure and surrounding riprap for the pressure conduits should be heavy enough to preclude loss of material. Use of 18" riprap around the outlet structure was recommended.

Robert Corrigan
for DANIEL E. PRICE
Chief, Project Management Branch

NAPEN-A (16 Jan 75) 4th Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works

DA, Philadelphia District, Corps of Engineers, Custom House, 2d & Chestnut Streets, Philadelphia, Pennsylvania 19106 20 JUN 1975

TO: Division Engineer, U. S. Army Engineer Division, North Atlantic
ATTN: NADEN-D, New York, New York 10007

1. The following comments are furnished in response to the comments by NAD and OCE as contained in the 1st and 2nd Indorsements and the inclosures thereto. The comments are numbered or lettered as in the respective Indorsements and inclosures.

a. Responses to NAD Review Comments dated 4 March 1975. DM No. 13, Bernville Protective Works (Inclosure 4, 1st Ind)

(1) Paragraph a. Paragraph 3-03b, should be revised as follows: Delete the last sentence and add the following sentence; "Guidelines for planting in EM 1110-2-301 have been applied to this project by elimination of any plantings in the embankment. The possibility of permissible planting by use of an overbuilt area was considered and not utilized due to limited construction space and restraints imposed by State and other criteria." Planting between stations 12+00/17+00, 40+70/41+70 and 47+30/56+20 are beyond the toe of slope and in compliance with the EM. Planting in the swale between stations 29+50 and 33+00 will be revised by eliminating plants between stations 29+00 and 29+50. Plants at stations 30+25, 30+75, 31+25, 32+00, 32+25 and 32+40 will be relocated to the adjacent roadside planting. Planting at the pumping station is at the toe of the embankment or in overbuilt areas and were placed to comply with the EM and selected, in the case of the shrubs, to be shallow rooted and expendable in case of pipeline repairs. Table 1 corrections - concur with corrections as noted. (Make pen and ink changes in Table 1.)

(2) Paragraph b. Excavation of soft clays is required. Extent of excavation will be delineated and costs included in the cost estimate.

(3) Paragraph c. Concur. Line 14 - the word "strength" should read "stretch". (Make pen and ink change)

(4) Paragraph d. The last sentence of paragraph 4-07e should be revised to read "... compacted by 2 passes ...." (Make pen and ink change)

NAPEN-A (16 Jan 75) 4th Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works

(5) Paragraph e. The pumping station is founded on the flood plain near the southern terminus of the levee. Three to 6.5 feet of alluvium consisting of interlayered silts, clays, silty sands and gravels overlie shale bedrock. Bedrock consists of variably weathered red, grey-green and grey shales striking N 40° - 55° E and dipping 40° - 45° southeast. Severe weathering extends to depths up to 10 feet below the ground surface. Groundwater is at or within 4 feet of the ground surface.

(6) Paragraph f. Seismic loads will be considered in accordance with ETL 1110-2-109, 21 October 1970, in the development of contract plans.

(7) Paragraph g. The ponding capacity has been increased by excavating the ponding area. The size of the pumps has been reduced from 200 cfs to 50 cfs, a reduction of 75%, and the motor size has dropped from 1000 horsepower to approximately 200 horsepower. This will result in reducing the demand factor charge for each pump start. The demand factors were considered in the estimates shown in the Alternate Studies portion of the Design Memorandum. With the decrease in motor size, the change in power supply voltage from 69 Kv to 13.2 Kv, resultant demand factor decrease, and the anticipated infrequent use of the pumps, electric motor drive is considered to be the most practical power source for the storm water pumps. Electrical service to operate the sump pumps and building equipment will be required in all cases.

(8) Paragraph h. Concur. The flanking levee will be relocated as recommended.

(9) Paragraph i. The details for transitioning the impervious core from zoning indicated on plate 12 for highway section at Station 25+30 to levee section at Station 27+60 will be covered in the contract plans and specifications.

(10) Paragraph j. Removal of bridges and miscellaneous structures is included in Design Memorandum No. 14, Reservoir Clearing. Demolition and removal of Robesonia Road (LR 06047) bridge and adjacent dam will be included in plans and specs for local flood protection at Bernville.

(11) Paragraph k. As indicated in Par. A-2-04 of Appendix A, material for the pervious fill zone at landside toe will be taken from the more pervious random soils containing less than 10 percent fines. Since this pervious fill will be selected from random fill excavations, a separate cost estimate item was not provided and was indicated by asterisk on page 12-5. Retention of this pervious zone is preferred to improve toe stability.

NAPEN-A (16 Jan 75) 4th Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works

(12) Paragraph l. Concur. The sluice gate manhole will be located off the levee roadway and the seepage diaphragm will be deleted.

(13) Paragraph m. Concur. Seepage diaphragms will be deleted.

(14) Paragraph n. Plate 32 has been superseded since the area-capacity curve, drainage area inflows and pump requirements have changed. Plate 32 is superseded by plates 6 and 7 of the inclosed Hydraulics Report. These plates represent the interior drainage routing with two different conditions on Northkill River. Plate 32 previously represented a single condition.

(15) Paragraph o. Concur. Velocity and water surface elevation profiles, as requested, included as inclosure.

(16) Paragraph p. A completed Eng Form 2086 will be forwarded, however, it is noted that the summary presented on plates A-5 through A-12 is much more useful in assimilation and interpretation of test results than the tabulation on Form 2086.

(17) Paragraph q. Additional borings for the relocated levee are presently being drilled and will be evaluated with regard to dewatering together with rechecking classifications as requested. Concerning the interpretations in comment q, this office does not agree that material shown by gradation curves from SAT-10 is "highly pervious" or that a "highly porous condition" is present. SAT-10 gradation curves indicate medium permeability according to commonly used charts (0.05 to 0.3 ft/min., see TM 5-818-1 and TM 5-818-5) and similar materials are present in other borings according to the descriptions except in the one case of SAT-3 where a higher permeability condition is accurately portrayed for bidders.

(18) Paragraph r. The correct classification is CH as shown on boring log for SAB-21U, plate A-2. There is no discrepancy between the boring log where blow counts were recorded in boring SAB-21 since the undisturbed samples were taken in the 2-to-6' depth interval in an immediately adjacent boring, SAB-21U.

(19) Paragraph s. The classifications as presented on plate A-6 for index design I, J, and L are correct. The gradation of these materials fail to meet the required coeffici nt of curvature and, therefore, have correctly been classified as poorly graded.

(20) Paragraph t. The shear test reports presented on plates A-7, A-9 and A-10 do indicate full saturation of samples was achieved as required by EM 1110-2-1902. The degrees of saturation indicated by NAD are for the initial condition before back pressure was applied in the R test.

(21) Paragraph u. Pending approval of the alternate interior drainage concept utilizing detention dams, the large conduit will not be required and a relatively small pipe culvert will suffice at this location.

b. Responses to NAD Review Comments dated 11 April 1975. NAD Report on Alternate Studies (Inclosure 3 - 1st Ind.)

(1) Paragraph a. Concur. Action has been instituted to relocate the substation to preclude possible loss of power. (See paragraph 1.b.(5) below for additional comments.)

(2) Paragraph b. Concur. As stated in the inclosed Hydraulics Report, the diversion facilities were checked for SDF (Spillway Design Flood). The SDF was taken as twice the SPF. By EM 1110-2-1411, the SPF is "generally equal to 40 to 60 percent of 'maximum probable' floods for the same basin." Therefore, the SDF used to check the diversion facilities is considered equivalent to the magnitude of a PMF.

(3) Paragraph c. Elimination of the floodwall around the sewage treatment plant with ponding above elev. 296.0 would inundate the sludge drying beds and flood below grade portions of the control building with the result that sewage treatment service for the Bernville area would be totally disrupted and damages to the facility would be sustained whenever the ponding level exceeded this elevation. Since relocation of the facility is not feasible, protection to maximum proposed ponding elevation 300.0 with ample freeboard allowance has been provided. Reorientation of the pumping station and regrading of the area on the northeast side of the facility will reduce the impact and extent of floodwall required.

(4) Paragraph d. In developing the cost table on page 5, the detention dams were assumed as fixed and the conduit sizes were varied with corresponding events.

(5) Paragraph e. With regard to sizing of the pumping station, the 300 cfs size was selected on the basis of providing Bernville with protection to elevation 300 in the event of an SPF. Elevation 300 is the maximum flooding level which can be attained without damage to the town, it is also the his-

torical maximum flood of memory and, therefore, any flooding above this elevation would be assumed to have been caused by the Blue Marsh project. Reduction in the station capacity by 50 cfs to 250 will result in increasing ponding to elevation 301 during an SPF with attendant damages estimated at $100,000. The estimated cost of one 50 cfs pump is coincidentally also about $100,000 including related appurtenances. It is our estimate, therefore, that reduction of one pump (50 cfs) at best only equals approximately the damages incurred by one SPF storm with ponding to elevation 301. It is also noted that the cost of one 50 cfs pump would represent less than 2% of the estimated cost for providing the protective works. We believe from the foregoing that minimizing the size of the pump station to effect a possible savings of 2% is inconsistent with the accuracy of other data upon which the desig.. s based and is not commensurate with the damages which could be sustained by such a reduction. We have reviewed the proximity of flood levels caused by the SPF and the elevation of the electrical substation and we are instituting action to have it relocated. In summary, with respect to the size of the pumping station, we believe that any savings in cost which could be realized by a reduction of 50 cfs in pumping capacity would not be significant with respect to the overall cost of the protection of Bernville and would not be worth the risks involved.

(6) Paragraph f. Concur. Damages shown include costs associated with clean-up, repairs and rehabilitation. Above elev. 303.0 (top of floodwall) damages to the sewage treatment facility would be sustained. Costs for restoring the facility to normal operation are included in the totals given for ponding levels greater than elev. 303.0.

(7) Paragraph g. Plate 36 of Design Memorandum No. 2, Hydrology and Hydraulics shows the positioning of the SPS for the Blue Marsh Reservoir and the Bernville location. The 96-hour SPS rainfall by the plate 36 positioning is 13.1 inches. Recentering the SPS over the Bernville diversion facilities yields a 96-hour SPS rainfall of 14.3. This results in a 9% increase for the rainfall increments. The increase is not significant enough to change pressure conduit or spillway sizes for the diversion facilities.

(8) Paragraph h. Concur. Further studies have enabled the ponding capacity to be increased somewhat by realignment of a portion of the levee and excavation of the ponding area. However, significant reduction of pumping capacity has not been realized due to constraints imposed by channel width and ponding area drainage requirements.

NAPEN-A (16 Jan 75) 4th Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works

(9) Paragraph i. ER 405-2-150 requires levees to be designed to an SPF coincident with maximum reservoir pool for urban or future urban areas. Considering the proximity of the levee, reservoir, and interior drainage locations a coincidental interior runoff for a levee design flood would be an SPF.

c. Responses to OCE comments per 2nd Indorsement dated 16 May 1975.

(1) Paragraph 1. Concur. The interior drainage feature of the Bernville protective works has been further reviewed and studied based on the concept proposed in the Alternate Studies report under Alternate E. The results of these additional studies and supplemental data and information developed are incorporated into this Indorsement as inclosures. Review conferences as recommended will be held as required and at such time when sufficient field data is available and the design is developed.

(2) Paragraph 2. Five additional borings are being made in the reach noted for the levee realignment and relocated pump station. These borings will penetrate the underlying shale and will be pressure tested to provide additional information on the character of the materials. Data developed and recommendations as to cutoff trench treatment will be presented at the review conference requested in the preceding paragraph.

(3) Paragraph 3. Concur. Final grading and treatment requirements will comply with the objectives of this comment.

(4) Paragraph 4. Concur. Pump discharge lines will be constructed using steel pipe. The 30-inch diameter lines now proposed should be more readily available than the larger size originally discussed.

(5) Paragraph 5. The economics of diesel vs. electrical power for the storm pumps will be investigated. However, since the pump station capacity has been reduced to less than one-half the original and the pump size has been reduced by 75 percent, it is anticipated that the total cost comparison will favor electrical power.

(6) Paragraph 6. It is not anticipated that the restart problem will exist in the revised pumping scheme. The pumps will not start until the storage capacity in the ponding area will allow the lead pump to operate for a minimum period of two hours. Multiple pumps of the same capacity rating will allow the unused pumps to be started for a second round of pumping if required. This will allow the first pumps to cool off over a period of hours before a restart would be required. However, if final design indicates a restart problem, valved by-passes or eddy-current clutches will be utilized to prevent excessive pump cycling.

NAPEN-A (16 Jan 75) 4th Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works

(7) Paragraph 7. Concur. Vapor-tight fixtures will be installed in the sump.

(8) Paragraph 8. Concur. Pump discharge lines will be located to pass over and not through the impervious core of the levee.

(9) Paragraph 9. Concur. The electrical calculations will be submitted with the plans and specifications.

(10) Paragraph 10. The statements as made in paragraph 6-02 of the General Design Memorandum for the subject project have been reviewed and reevaluated. This reevaluation was based on the concept of the proposed Bernville protective works under Alternate E in the Alternate Studies Report and subsequent studies thereto. As a result of this reevaluation, it has been determined that the statement that the provision of protective works would be more economical and practical than the acquisition of pertinent properties is still applicable and valid.

2. Pending final approval of the Blue Marsh Lake Design Memorandum No. 13 - Bernville Protective Works, including the interior drainage feature, we are proceeding with the preparation of the plans and specifications for the construction of the protective works as presently proposed.

3. In order to insure that this effort may proceed in a timely fashion and to meet with the current schedule for submission of the plans and specifications, your suggestion of a coordination meeting is concurred in. It is recommended that pending your review of the data provided in this Indorsement, a coordination meeting be held in the Philadelphia District Office the second week of July, with a tentative date of 8 July 1975.

FOR THE DISTRICT ENGINEER:

Worth D. Phillips

WORTH D. PHILLIPS
Chief, Engineering Division

18 Incl (6 cys ea.)
Replace 3 Incl
Added 12 Incl
(See list on next page)

NAPEN-A (16 Jan 75) 4th Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works

18 Incls (6 cys ea.)
Replaced 3 Incls (copies) - originals w/d by OCE
(modified as noted)
2. NAPEN-D ltr dtd 4 April 75 w/Alternate Studies Report - March 1975
   a. Added: NADEN-TH (4 Apr 75) 1st Ind dtd 27 May 75
3. NAD Review Comments, Report on Alternate Studies, dtd 11 Apr 75
4. NAD Review Comments, DM 13, Bernville Protective Works, dtd 4 Mar 75

Added 15 Incl
5. Pump Station - Site Plan
6. Pump Discharge Line (Profile)
7. Pump Station Layout
8. Pump Station - Section A-A
9. Pump Station Sump Layout
10. Tributary #1 - Site Plan
11. Tributary #1 - Profile
12. Tributary #2 - Site Plan
13. Tributary #2 - Profile
14. Hydraulics Report - Bernville Interior Drainage
15. Ponding Area - Capacity Curve
16. Pumping vs Ponding Graph
17. Pump Station - Electrical System Report
18. Pump Station - Mechanical Report
19. Velocity and Water Surface Elevation Profiles

NADEN-MG (16 Jan 75) 5th Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works

DA, North Atlantic Division, Corps of Engineers, 90 Church Street
New York, NY 10007 7 July 1975

TO: HQDA (DAEN-CWE-B) WASH DC 20314

1. The response to NAD and OCE comments is considered satisfactory. Approval of the supplemental data is recommended subject to the following comments:

a. 4th Ind., para. 1b(2). The referenced NAD comment was intended to direct attention to the possibility that floods exceeding conduit capacity could cause increased hazards to properties downstream of the dams due to redirection of flow and obstruction of the natural waterways with the project in place. This aspect should be reviewed and results furnished.

b. Page 2, incl. 14. To accommodate possible pump malfunction or loss of power during a sudden, localized storm, consideration should be given to providing for somewhat greater than an annual event by means of gravity outflow.

c. Incl. 14, page 1, para. 1b. Since spillway design is based on the assumption that the pressure conduits will be blocked, assessment should be made of the need for special structural provisions, such as trash racks.

d. Assessment should be made of the need for riprap protection at the outlets for the pumping station, gravity outlet structure, and the pressure conduits below the two detention reservoirs.

e. During final design, consideration should be given to providing top of levee walkways where feasible.

2. A coordination meeting, as requested by your office in para. 3 of 4th Ind., has been scheduled in the Philadelphia District Office for 21 July 1975 at 10 a.m. It is requested that representatives from your office attend.

FOR THE DIVISION ENGINEER:

R. L. [signature]
for THOMAS J. BEVACQUA
Acting Chief, Engineering Division

18 Incl (quad)
wd 2 cys ea

cc: DE Phila. ATTN: NAPEN-A

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

20 JAN 1975

SUBJECT: Blue Marsh Lake Design Memorandum No. 13 - Bernville Protective Works

Division Engineer, North Atlantic
ATTN: NADEN

1. In accordance with ER 1110-2-1150, there are inclosed 16 copies of the subject design memorandum for review and approval.

2. Reference is made to NAPEN-D 3rd Ind of 7 January 1975, to NADEN-TH letter of 8 November 1974, subject, Blue Marsh Dam and Reservoir, Pa., Relocation of Highways and Bernville Local Protection. As shown on the inclosure to that letter, the award of a construction contract for protective works at Bernville is now scheduled for August 1975. In order to meet this schedule, it is imperative that review comments be received within 60 days.

3. Pending approval of D.M. 13, Bernville Protective Works, we are proceeding with the preparation of plans and specifications.

FOR THE DISTRICT ENGINEER:

1 Incl (16 cys)
As stated

for [signature]
WORTH D. PHILLIPS
Chief, Engineering Division

NADEN-MG (16 Jan 75) 1st Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13 - Bernville Protective Works

DA, North Atlantic Division, Corps of Engineers, 90 Church Street
New York, N.Y. 10007 11 April 1975

TO: HQDA (DAEN-CWE-B), WASH DC 20314

1. Reference is made to NADEN-MG letter dated 23 January 1975, subject as above, which furnished 6 copies of subject memorandum for concurrent review by your office.

2. During review of the interior drainage provisions presented in the subject DM, it was determined that, due to the rapid hydrologic response of the small drainage area above Bernville on Northkill Creek, it was likely that gravity outflow of runoff from major rainfall events would be blocked. Routing studies further disclosed that during the levee design flood, with the proposed 800 cfs pumping plant in operation, interior drainage could pond to within 4-6 feet of the elevation of the levee design water surface, affecting essentially the entire protected area and causing excessive flood damage.

3. Following the above analyses, studies were made of alternate plans that would provide a higher degree of protection against interior flooding. As indicated by Alternate E in inclosure 2, the District has found that by diverting two streams which drain about 80 percent of the interior drainage area, and increasing the ponding capacity by excavation, a high degree of protection can be provided and the size of the pumping plant substantially reduced. This scheme would include two SPF-sized pressure conduits with intake dams containing about 30-45 acre feet of storage at spillway crest, and a pumping plant with capacity of about 290 cfs. The total Bernville project cost would be essentially the same as initially proposed in DM No. 13.

4. In view of the critical time schedule for this project, it is recommended that the concept embodied in Alternate E be approved as a basis for preparation of plans and specifications subject to the NAD review comments in Inclosure 3. In addition, it is recommended that, except for interior drainage provisions, DM No. 13 be approved subject to the NAD review comments in inclosure 4.

5. In the event there are concerns regarding the proposed project design, a meeting with NAP and NAD personnel will be scheduled at your convenience.

FOR THE DIVISION ENGINEER:

M. SCHECHET
Chief, Engineering Division

4 Incl
1. 12 cys w/d
Added 3 Incl (13 cys ea)
2. NAP ltr 4 Apr 75 w/incl rpf
3. NAD Review Comments 11 April 75
4. NAD Review Comments 4 March 75

DAEN-CWE-B (NAPEN-D, 16 Jan 75) 2nd Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13 - Bernville Protective Works

DA, Office of the Chief of Engineers, Washington, D.C. 20314 16 May 1975

TO: Division Engineer, North Atlantic, ATTN: NADEN-MG

1. Approved, subject to the comments of the Division Engineer in the 1st Indorsement and inclosures thereto and to the comments in the following paragraphs. The concept embodied in Alternate E, interior drainage, is satisfactory; however, since the pumping station will be materially affected by Alternate E, approval of the interior drainage feature is withheld pending further studies and review and approval of supplemental information resulting therefrom. In addition, in view of the proposed schedule for this project and since the two detention dams remain under design, a review conference is suggested at such time as sufficient field data is available and the design is developed.

2. Paragraph 4-05b and Plates 8, 10 and 13. In the levee reach south of Station 48±, the more highly fractured and deeply weathered foundation rock at the core trench contact, in combination with the proposed landside drainage ditch cut into or through the pervious foundation gravels, could lead to damaging underseepage with successive pool fluctuation. Care should be exercised to contractually allow for its deepening to a sound condition, and provisions for sidewall filters and rock surface treatment should be included.

3. Paragraph 4-07a and Plates 28 through 31. A discussion should be furnished on the rehabilitation of borrow areas Alpha and Bravo. The planting plans shown on these plates do not include the borrow areas. In addition to the criteria stated in paragraph 4-07a, the location of the borrow areas should be based on an evaluation of the effects the borrow areas would have on the environment.

4. Paragraph 7-03d. All pump discharge lines should be constructed using steel pipe.

5. Paragraph 7-04c. In view of the cost involved in obtaining electric power, it appears that consideration should be given to using deisel engine for powering the storm water pumps.

6. Paragraph 7-04d. Motors of the proposed size are not suited to a cycling type service where frequent starts are required. If such operation is envisioned a valved bypass should be installed to bypass a part of the pump discharge back to the sump; frequent starts can thus be avoided.

DAEN-CWE-B (NAPEN-D, 16 Jan 75) 2nd Ind 16 May 1975
SUBJECT: Blue Marsh Lake Design Memorandum No. 13 - Bernville Protective Works

7. Paragraph 7-04g(1). Sufficient lighting to preclude the use of portable lights for routine maintenance should be provided in the sump.

8. Plate 24. The pump discharge lines should go over top of the impervious core rather than through it.

9. Appendix C. Electrical calculations including fault current calculations used for determining the rating and interrupting capacity of the circuit breakers and fuses should be incorporated in this appendix.

10. In paragraph 6-02 of the General Design Memorandum for the subject project, there is a statement that the Bernville Protective Works were not presented in the authorizing document except for a need of minor land acquisition; upon further analysis of the standard project flood, it was then determined that the provision of protective works would be more economical and practical than the acquisition of pertinent properties. The subject design memorandum should contain a statement as to whether this is still the case.

FOR THE CHIEF OF ENGINEERS:

wd all incl

C. E. Stanton
for HOMER B. WILLIS
Chief, Engineering Division
Directorate of Civil Works

NADEN-MG (16 Jan 75) 3rd Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13 - Bernville Protective Works

DA, North Atlantic Division, Corps of Engineers, 90 Church Street, New York, NY 10007 22 May 1975

TO: District Engineer, Philadelphia ATTN: NAPEN-D

1. To note that the subject Design Memorandum is satisfactory as a basis for further planning subject to OCE and NAD comments and that approval of the interior drainage feature is withheld pending further studies and review of the supplemental information resulting therefrom.

2. Information on a tentative schedule for the review conference suggested by OCE should be furnished this office as soon as possible.

FOR THE DIVISION ENGINEER:

M. SCHECHET
Chief, Engineering Division

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

4 APR 1975

SUBJECT: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works

Division Engineer, North Atlantic
ATTN: NADEN-T

1. As requested during our meetings of 7 and 25 March 1975, we have reviewed the proposed interior drainage at Bernville, Pennsylvania. Our study revealed that due to the small drainage area involved, the various events for interior drainage coincident with high stages in the reservoir as presented in the DM for Bernville are of high frequency and not in general agreement with other project design criteria. We feel protection provided behind the leveed areas against interior flooding should be in the same range as that afforded by the levees against reservoir flooding of the Boro.

2. The District has therefore made a study of alternate methods to provide increased protection and has presented the results along with a recommendation in the inclosed report.

3. It is requested that prompt review of this study be accomplished by your office. Upon receipt of your comments on this report, the District will prepare formal revisions to DM #13, Bernville Protective Works. Pending approval of these changes we are, however, proceeding with those portions of the plans and specifications not directly affected by these changes.

4. It should be noted that an exploration and testing program has been develcped for the design of the two detention dams. Data from these explorations and the design for the dams, however, are not expected to be available for the revisions noted above. This information will be submitted to NAD at a later date for review. In order to expedite approval of this data, it is further requested that authority be obtained for review and approval at Division level.

FOR THE DISTRICT ENGINEER:

Worth D. Phillips

1 Incl
As stated

WORTH D. PHILLIPS
Chief, Engineering Division

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

Incl 2

NADEN-TH (4 Apr 75) 1st Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works

DA, North Atlantic Division, Corps of Engineers, 90 Church Street, New York, NY 10007 27 May 1975

TO: District Engineer, Philadelphia ATTN: NAPEN-D

1. Reference is made to NAPEN-D basic letter dated 16 January 1975, subject as above, and Indorsements 1 through 3, thereto, by NAD and OCE.

2. Further study of the interior drainage feature based on the concept of recommended Alternate E should proceed in accordance with NAD and OCE comments in the referenced chain of correspondence.

3. Attached NAD review comments on Inclosure 1 were furnished previously in connection with 1st Indorsement, dated 11 April 1975, referred to in paragraph 1, above.

FOR THE DIVISION ENGINEER:

1 Incl
wd incl 1
Added 1 Incl
2. NAD Review Cmts dtd 11 Apr 75

M. SCHECHET
Chief, Engineering Division

BLUE MARSH LAKE
DESIGN MEMORANDUM NO. 13
BERNVILLE PROTECTIVE WORKS

ALTERNATE STUDIES
MARCH 1975

1. General

The potential flooding of Bernville Boro has been increased by construction of the Blue Marsh Lake Project and therefore is not a standard local flood protection project, with the locals sharing the cost. In this case, the Corps of Engineers would purchase all real estate, pay for all construction, relocations, and operate and maintain the entire protection system.

Because the area to be protected by levees was not subject to the same level of flooding prior to the construction of the reservoir project, substantially higher degree of protection against interior flooding should be provided.

2. Present Flooding Conditions

The flooding potential at Bernville without local protective works or the Blue Marsh Dam, was investigated for the existing conditions. The 10, 50, 100 yr., and SPF event were routed through the area. The results indicate probable flood levels at Bernville as follows:

Pre-Project Flooding

Event	Elev
10 - year	300.1
50 - year	301.6
100 - year	302.3
SPF	306.2

3. Ponding Area

The existing topography is such that a natural low lying area encompassed by contour Elevation 300 immediately behind the protective levees is relatively uninhabited and presently acts as an overbank flood plain. This makes an ideal ponding area and was therefore selected and used in DM #13. Immediately above elevation 300, commercial establishments and private residences have been constructed along with a 13.2 KVA substation at elev 301.5 which feeds electric energy to the town. Because of the proximity of improvements above elevation 300, it was fixed as the upper allowable elevation of flooding from project induced flooding. Intermittent flooding above this elevation would require purchase of flowage easements, and relocation of the 13.2 KVA substation. Flooding above elevation 303 would inundate the sewage treatment facility adjacent to the pumping station.

It should be further noted that in all meetings with locals, Elevation 300 was given as highest flooding elevation, and Real Estate acquisition has been based on same.

4. Alternate Plans Studied

Four Alternate plans were investigated and priced to determine the most economical method of handling various interior design storms coincident with high reservoir stages. Several plans were investigated under each alternate, such as; tie back levees, different locations for detention dams, and increasing the volume of the ponding area. Several site plans were checked for each alternate, but only the most acceptable and economical plan is briefly presented below.

ALTERNATE A: Provide interior drainage protection as shown in DM #13, Bernville Protective Works, utilizing a larger pumping station to provide additional protection. This plan would also require varying the size of the tw large culverts under LR 310.

ALTERNATE B: Diversion of upper tributary (#1) by means of a dam and a concrete conduit. This plan would divert inflow directly to the Northkill Creek thus reducing pumping requirements, and the required size of the long culvert under LR 310. The dam would have a top elevation of 331.5 with a 50' wide spillway cut into existing rock with a crest elevation of 325. This plan requires additional real estate mostly in the form of flowage easement.

ALTERNATE C: Diversion of the middle tributary (#2) by means of a dam and a concrete conduit. The conduit would divert the natural inflow directly to the Northkill Creek, thus reducing the pumping requirements for interior drainage. The dam would consist of an earthfill section with a top elevation of 325, and a 100' wide gravity concrete spillway with a crest at elevation 320. This alternate would also reduce the size of the culvert under LR 310, and require additional real estate mostly in the form of flowage easement.

ALTERNATE D: This alternate would combine B and C above, i.e., divert both the upper (#1) and middle (#2) tributaries through culverts to the Northkill Creek thereby substantially reducing the size of pumping station required under any design storm. (This is the recommended Plan.)

ALTERNATE E: Same as "D" above plus excavation of ponding area. It is anticipated that some portion of the excavated material will be used in the construction of the levee. The excavation will be graded to drain to the gravity outlet and seeded.

5. Costs

a. The estimated cost of each alternate was prepared for 10 yr, 50 yr, 100 yr, and SPF events for 2 different ponding elevations. One being elevation 300 (no-damage) and the other being the elevation of potential flooding prior to the project for any one event. The latter ponding elevation varies from El 300 to El 306. The estimated costs for all alternates include real estate and relocations. This information is summarized below along with the required pumping in cfs for the pumping station.

b. It can be seen from the following summary that the cost of ponding to pre-project damage levels (Elev 300-306) is greater than a no-damage level (Elev 300) and is due to additional relocation and real estate cost.

PLANS	Ponding Elevation El 300		Ponding Elevation Varies 300-306		
	NO-DAMAGE		PRE-PROJECT FLOODING		
Alternate A	Pumping Required CFS	Total Project Cost	Pumping Required	Ponding Elev	Total Project Cost
(DM #13) 10 year event	800	$7,800,000	790	300.1	$7,600,000

50 year event	1000	8,900,000	900	301.6	8,900,000
100 year event	1100	9,100,000	1000	302.3	9,500,000
SPF event	2100	12,600,000	1600	306.2	12,200,000
<u>ALTERNATE B</u> (Divert #1)					
10 year event	350	7,000,000	340	300.1	6,800,000
50 year event	600	7,500,000	500	301.6	7,900,000
100 year event	600	7,600,000	500	302.3	8,400,000
SPF event	1100	9,600,000	700	306.2	9,400,000
<u>ALTERNATE C</u> (Divert #2)					
10 year event	400	7,500,000	390	300.1	7,400,000
50 year event	700	8,500,000	600	301.6	8,400,000
100 year event	710	8,600,000	600	302.3	8,900,000
SPF event	1340	10,700,000	900	306.2	10,600,000
<u>ALTERNATE D</u> (Divert #1 & #2)					
10 year event	45	6,300,000	40	300.1	6,100,000
50 year event	100	6,600,000	50	301.6	6,700,000
100 year event	110	6,900,000	40	302.3	7,100,000
SPF event	340	8,000,000	120	306.2	8,600,000
<u>ALTERNATE E</u> (Divert #1 & #2 plus excavation of Ponding Area)					
100 year event	60	7,300,000	15	302.3	7,300,000
SPF event	290	7,900,000	90	306.2	8,400,000

c. In addition to the alternates above, some further studies were made under Alternate E to determine the effect of a fixed size pumping station on the ponding elevation for various interior storms. The results are as follows:

Ponding Elevation

Pumping Station Capacity

Event	100 cfs	150 cfs	200 cfs	300 cfs
10	El 296.5	El 296.0	El 295.3	293.6
50	299.0	297.2	296.5	294.0
100	299.5	298.3	297.1	295.3
250	302.5	301.2	300.0	297.5
SPF	306.0	304.5	303.0	300.0

Those ponding elevations below the dark line would cause damage and require real Estate acquisition and/or relocations.

d. The estimated cost of Real Estate and Relocations for various elevations are as follows:

Elev	Increment Cost	Total Cost
300	0	0
301	$250,000	250,000
302	220,000	470,000
303	380,000	850,000
304	260,000	1,110,000
305	140,000	1,250,000
306	60,000	1,310,000

e. An example of the cost of damages versus increased pumping (without excavated ponding area) is shown below.

Ponding Elevation	R. E. Damages Increment	Total	Pumping CFS	Total Cost Pumping Station
300	0	0	340	1,800,000
301	100,000	100,000	300	1,700,000
302	90,000	190,000	260	1,600,000
303	90,000	280,000	220	1,500,000
304	100,000	380,000	185	1,400,000
305	80,000	460,000	150	1,300,000
306	90,000	550,000	120	1,200,000

6. HYDROLOGY.

a. Hydrology - Standard Project Floods and 10 year, 50 year and 100 year floods were developed for interior drainage Tributaries 1, 2 & 3. The Standard Project Flood hydrographs were developed by determining the runoff from each tributary during the occurrance of an SPF event generally centered over Bernville. (This is the same centering used in determing the SPF for the Blue Marsh Dam). The frequency floods (10-50-100 year) were developed from frequency precipitation as presented in U. S. Weather Bureau Technical Paper N. 40.

b. Detention Dams - Dams proposed on Tributaries 1 and 2 were designed to detain flood peaks and pass flows directly through pressure conduits into Northkill Creek. Spillways for these projects were sized by routing the SPF through each with the pressure conduit assumed blocked. These routings

developed the maximum water surface level in each pool for various sized spillways. Freeboard allowances were added to the water surface elevation to determine the top of dam elevation. To determine the effect of the proposed dams and spillways (Tributaries 1 and 2) on a Spillway Design Flood, the SDF was routed through the reservoirs with the pressure conduits assumed unobstructed. The SDF was approximated by doubling the SPF. The resulting routings indicate that the maximum pool levels would be 328.6 ft. SLD (vs. 328.4' for the SPF routing with the conduit blocked) for Tributary #1 and 322.2 ft. SLD for Tributary #2 (vs. 321.9' for the SPF routing).

c. Pressure Conduits - Pressure conduits were designed for each dam. They were sized to keep the SPF and the frequency floods below the proposed spillway crest elevation. SPF routings used in sizing the pressure conduits were done with coincident SPF elevations on the Northkill Creek. Two conditions were investigated. First the SPF was assumed coincident with Northkill Creek SPF water surface elevation when Blue Marsh Lake was at summer conservation pool level (elevation 290.0) and second with the pool level at spillway crest (elevation 307.0). Cost estimates presented above were based on the latter assumption. Pressure conduit siting for the frequency floods was accomplished by routing each flood with levels on the Northkill Creek assumed at a maximum RDF (Reservoir Design Flood) elevation with Blue Marsh Lake at elevation 307.0.

d. Ponding Area Pump Sizing - Pumping capacity to pass the SPF, 10 year, 50 year and 100 year flood events through the ponding area were developed for two criteria. One was to keep the interior drainage elevation below that which would occur naturally for a given event. The other criteria was to keep the elevation below the non-damaging elevation of 300.0. A typical performance

curve showing an SPF inflow hydrograph, the coincidental stages in Northkill Creek and the resulting ponding levels in the ponding area with an assumed pump station capacity of 300 cfs is presented in Attachment 1.

Increasing the ponding area by excavation will provide for a smoother operation of pumps and will reduce pumping requirements. For the SPF event with Alternate E in effect, pumping requirements will be reduced from 340 cfs to 290 cfs (maximum ponding to non-damaged level of 300 ft SLD) and from 120 cfs to 90 cfs (maximum ponding to pre-project flood level). The corresponding required pump capacities to handle the 100 year event are 60 cfs and 15 cfs, respectively.

7. Conclusion.

The investigations, studies, and cost estimates indicate that Alternate ~~D~~ E (diversion of tributary #1 and #2) with ponding held at elevation 300 is the most advantageous to the government. Discussion with the local governments revealed no objection to this plan.

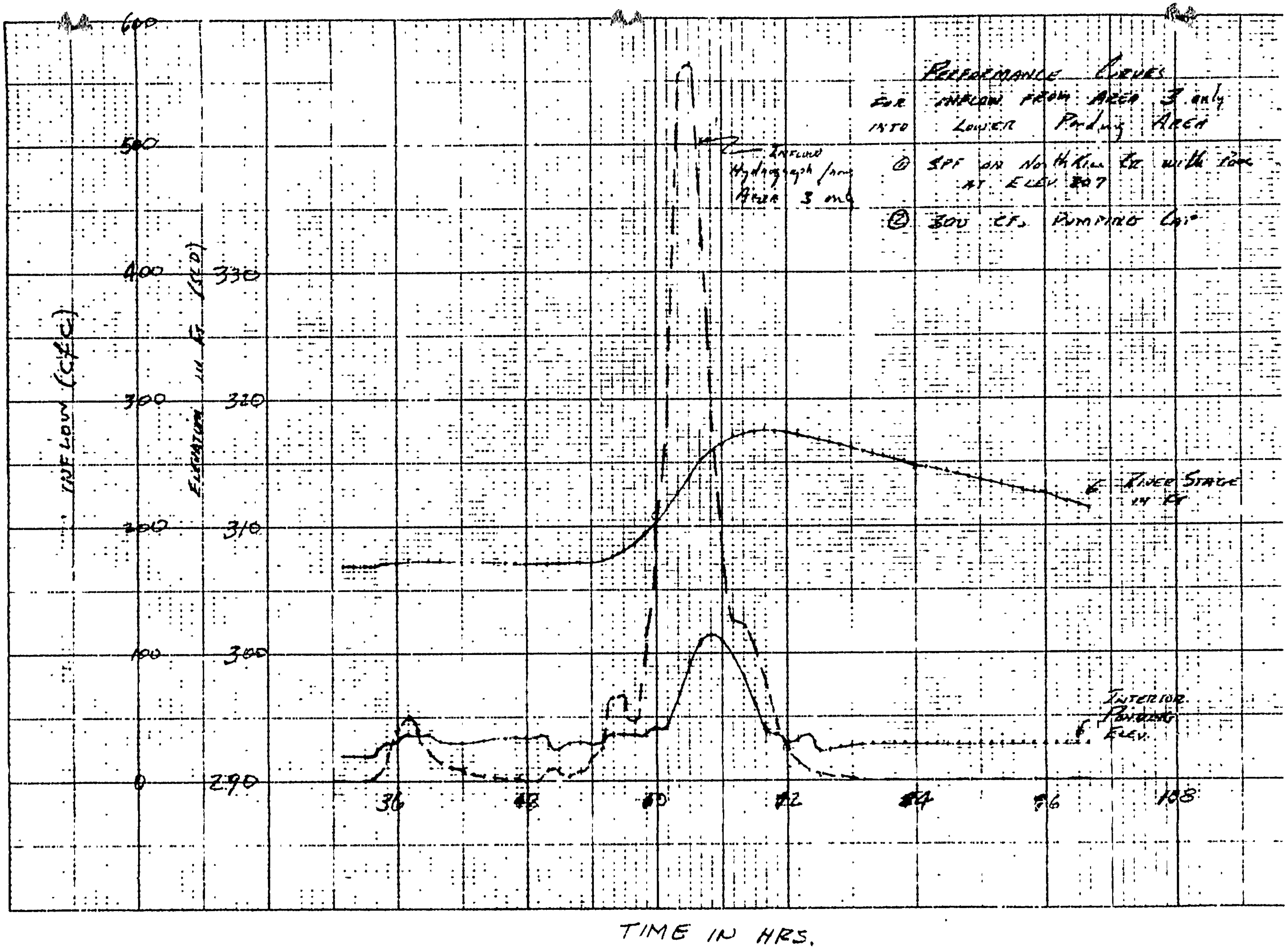
The ponding area presented in DM #13 will be enlarged through excavation and graded to drain. The increased capacity will give a smoother operation of the pumps and reduce pumping requirements. The town has indicated that it would like to use part of the ponding area for ball fields. Decision on this matter of the ball fields will be deferred pending final design.

Recommendation.

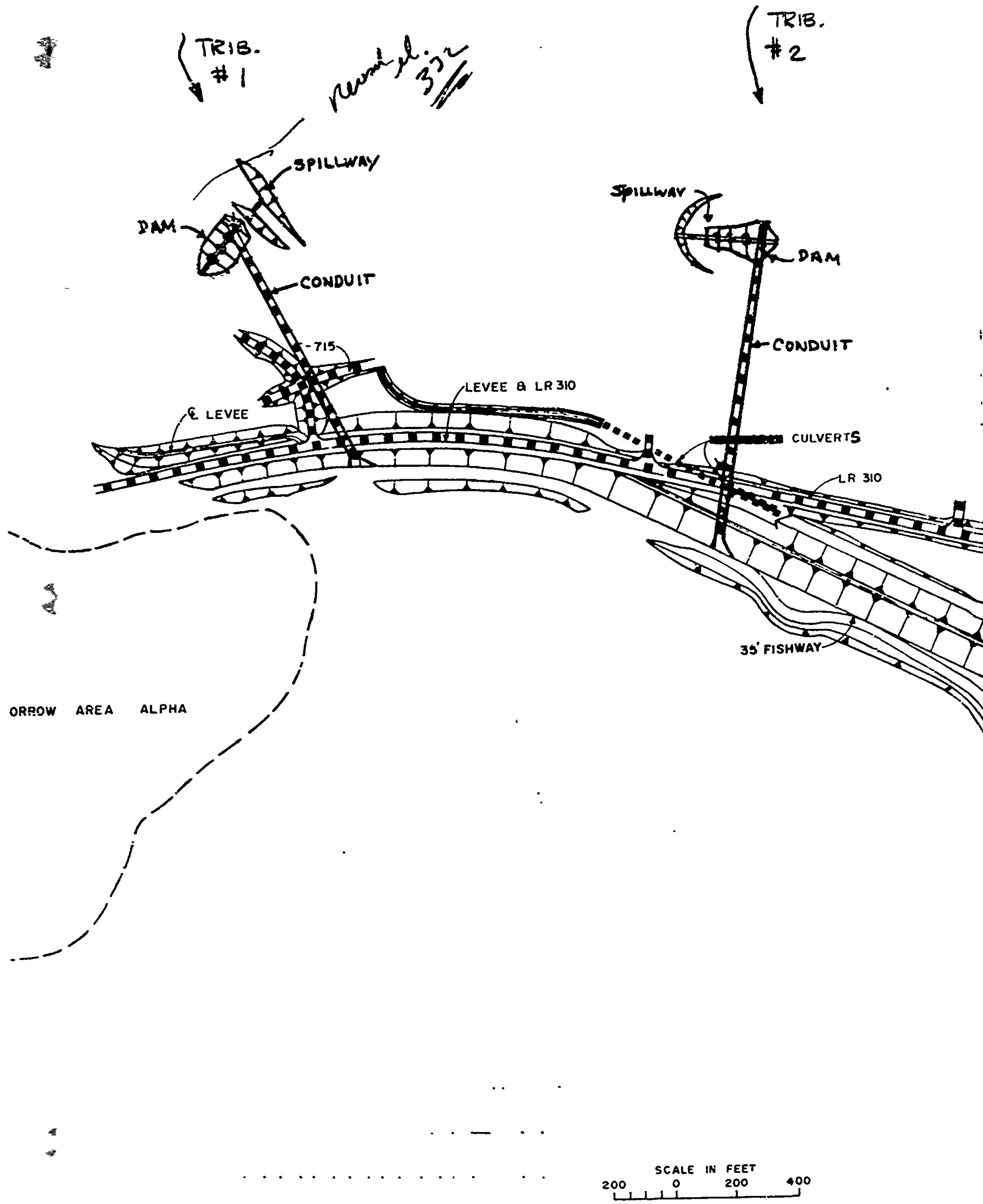
a. In accordance with ER 405-2-150 para. 8d, the construction of the protective works for the borough of Bernville necessitated by the construction of Blue Marsh Dam & Lake, will be designed to protect the Boro against an interior storm equivalent to that protection provided by the levees against

reservoir flooding (SPF).

b. Further, it is recommended that this protection be accomplished through the use of diversion of interior drainage through the levees and excavation of the ponding area in lieu of a larger pumping station. (Alternate E, see Attachment 2).



Attachment 1



Attachment 2

11 April 1975

NAP REPORT ON ALTERNATE STUDIES - MAR. 1975
BERNVILLE PROTECTIVE WORKS

NAD REVIEW COMMENTS

a. Paragraph 3, page 2. It is understood that the cost of relocating the electric substation might be as low as $150,000. This should be included in recommended Alternate E in order to preclude the loss of power to the area in the event operating difficulties are encountered at the pump station during a storm.

b. Paragraph 4, page 4. The diversion facilities for tributaries 1 and 2 should be checked for floods up to PMF magnitude to insure that increased hazards will not occur below the dams due to higher velocities and/or stages.

c. Paragraph 5, page 4. It is not clear whether cost savings could be realized through elimination of the wall at the sewage treatment plan for the recommended scheme. This should be reviewed.

d. Paragraph 5b, page 5. For clarification, it is understood that for Alternates B-E, the size of the intake dam is fixed while the size of the pressure conduit (s) varies to correspond with the indicated event.

e. Paragraph 5c, page 6. There appears to be little economic justification for providing a pump station on the order of 300 cfs. In view of the remote possibility of the extreme SPF event, the relocation of the electric substation recommended in paragraph a above, the low residual damage on an annual basis, and the fact that easements would not normally be required to an extreme flood level, consideration should be given to allowing the SPF event to exceed elevation 300 somewhat, thereby reducing required pump capacity.

f. Paragraph 5e, page 7. It is understood that the damages in the third column of the table assume that the electric substations has been relocated. However, the nature of the indicated damage, including the handling of the sewage treatment plant, is not clear. This should be carefully reviewed in connection with the evaluation of paragraph e, above.

g. Paragraph 6a, page 7. Under the recommended scheme, the dams and conduits for tributaries 1 and 2 are sized for the SPF component of the reservoir SPF. Consideration should be given to using the SPF for each individual tributary, if significantly larger.

h. Paragraph 6d, page 9. Additional economic evaluation studies should be made to determine the feasibility of further enlarging the ponding area and reducing pumping capacity, thereby tending to minimize O & M costs.

i. Paragraph 7a, page 9. While this office does not interpret the reference as requiring design for an interior storm equivalent to that used for a levee at a reservoir project, consideration of the disposition of the interior runoff coincident with the levee design flood is pertinent.

INCL 3

' March 1975

NAD REVIEW COMMENTS
DM 13, BERNVILLE PROTECTIVE WORKS

a. Paragraph 3-03b. The planting guidelines in EM 1110-2-301 are applicable to this project regardless of the limitations and restraints indicated. The roots of plantings may not penetrate the levee structure and the density of plantings should not prevent the inspection of toe areas for boils during flood periods. A review and revision of the location of plantings between Station 12+00 and 17+00, 29+50 and 33+00, 40+70 and 41+70, and 47+30 and 56+20 should be accomplished. The followng plant species are shown incorrectly in Table 1:

(1) "Pinus sylrestris" should be Pinus sylvestris.

(2) "Hemorocallus fulva - common Daylily" should be Hemerocallis fulva - Tawny Daylily.

(3) "Shus sp." should be Rhus sp.

(4) "Rubus strigosus - Wild Raspberry" should be Rubus idaeus strigosus-American Red Raspberry.

b. Paragraph 4-05c. If final design requires excavation of soft clays beneath the embankment, the areal extent of these deposits should be delineated before preparation of final plans and specifications so that consideration may be given to this item in the cost estimate.

c. Paragraph 4-06a. Line 14 - change "strength" to read "stretch".

d. Paragraph 4-07e. The number of passes should be indicated.

e. Paragraph 7-01. The foundation conditions for the pumping station and drainage structures should be covered.

f. Paragraph 7-02h. Seismic loads should be considered in accordance with ETL 1110-2-109 (21 October 1970).

g. Paragraph 7-04. In determining pumping plant costs consideration must be given to demand charges. When these charges are considered an analysis should be made as to the most economical plant size as well as whether direct engine drives should be considered. The cost of creating a greater ponding area may be economically justified when all plant costs are considered.

h. Plates 3 and 11. Consideration should be given to moving the flanking levee with its nearly 20-foot height and gated gravity outlet structure to a point about 800 feet upstream close to the divide where the height would be about 5 feet and a gravity outlet structure would not be required. The length of the top of the flanking levee would be about the same for either location.

NCL 3

NAD Rev Cmts (Cont d) 4 March 1975
SUBJECT: DM 13, Bernville Protective Works

i. Plates 5 and 6. In the highway section which functions as a levee, the location of the impervious core centerline should be indicated. Horizontal transitions should be carefully developed to insure ease of placement and proper compaction. The details of the crossing of the core beneath the road structure should also be included.

. Plate 8. The removal of the existing Robesonia Road Bridge and the .. -foot high dam located downstream of the bridge is not mentioned in the text nor shown as a cost item.

k. Plate 13. Typical S ctions-Sta. 29+35 to 53+30 and Sta. 56+35 to 58+90. The reason for placing pervious fill at the toe of the protected side of the levee is not clear. A positive, reasonably good cut-off will be effected with the impervious core on rock and submergence of the levee will be infrequent so that there will be little underseepage or through-seepage. Also, the cost estimate (Section 12) does not contain a pervious fill item. The deletion of this item for sake of economy is recommended.

l. Plate 21. For final design it is recommended that (a) the sluice gate manhole be moved off the crown of the levee in order to provide sufficient clearance for the gate stem from the gravel roadway and (b) the seepage diaphragm be deleted.

m. Plate 22. The seepage diaphragm should be deleted.

n. Plate 32. The upper left graph shows interior drainage inflow, outflow, and ponding elevation vs. time in hours. At 3 /2 hours the outflow is 650 cfs with the pond level below elevation 293 feet. At 7 hours the outflow is also shown as 650 cfs with the pond at elevation 293 feet. Since the control sill to the pumping station is at elevation 293.0 feet (plate 8), pumping outflow would be zero with the pond at elevation 293 feet. The gravity outlet with the pond at this level would pass 20 cfs (see graph in lower left corner of Plate 32). Zero cfs pumping plus 20 cfs g vity flow does not add up to the indicated 650 cfs outflow. This apparent inconsistancy should be explained.

o. Plate 35. A velocity profile should be included. In addition, the levee stationing should be shown, or preferable, creek stations should be established and indicated on plan views and profiles for ease of cross referencing.

p. Appendix A. Engineering Form 2086 should be used to summarize all test data.

q. Plates A-1, A -2, and A-3. The gradation curves of the lower foundation material from SAT-10 indicate that the material is a highly pervious zone.

NAD Rev Cmts (Cont'd) 4 March 1975
SUBJECT: DM 13, Bernville Protective Works

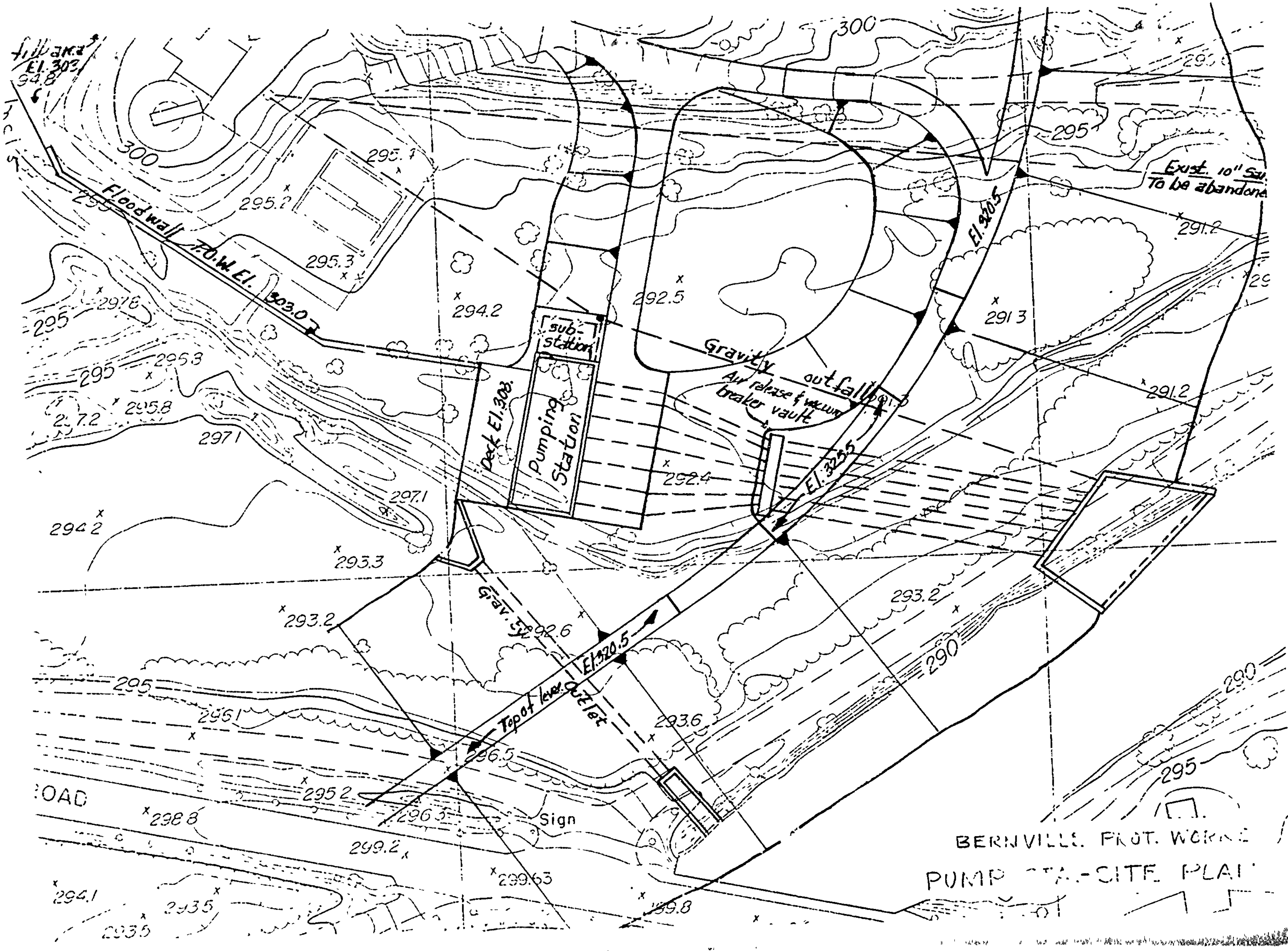
With the exception of the coarse to fine gravel strata in SAT-3, the classifications in the other borings and test trench logs do not reflect, or convey to prospective contractors, this highly porous condition. It will be necessary to dewater this zone forthe proper construction of the cutoff. It is therefore recommended for the development of contract plans that classifications be checked and corrections be made where necessary. Also, additional field tests should be accomplished and presented to accurately portray this condition.

r. Plates A-2, A-6 and A-12. Boring SAB-21 on Plate A-2 indicates that the material is CH whereas Plates A-6 and A-12 show it to be OH. A clarification is required. Also, the stratification and logging information appear in error when compared to the test data. Undisturbed samples were apparently taken from 2 to 6 feet and blow counts are indicated on the logs.

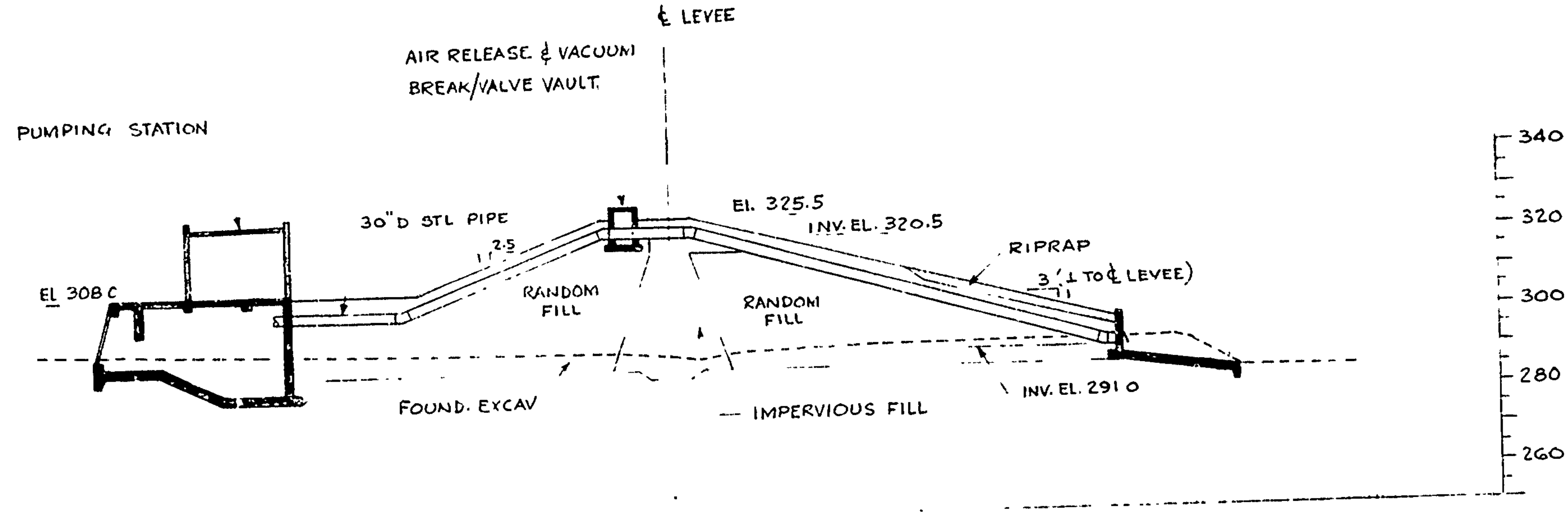
s. Plate A-6. Index Design I, J, and L appear to be GW or GW-GC materials. It is requested that this as well as the log classifications be reviewed.

t. Plates A-7, A-9, and A-10. EM 1110-2-1902 requires that R tests be fully saturated by means of back pressure. Test data on the indicated plates show 62 to 80 percent saturation. The reasons for using these lower saturations should be indicated.

u. Appendix C, Page 19. The computed corner bearing pressure of roughly 5 tons per square foot is considered high, even though the soil is confined under 25 feet of fill and will be well compacted. It is recommended that structural plate steel pipe arches with corner radius equal to 31 inches be used in lieu of the 18 inches presently indicated This would reduce the corner bearing stress to roughly 3 tons per square foot.

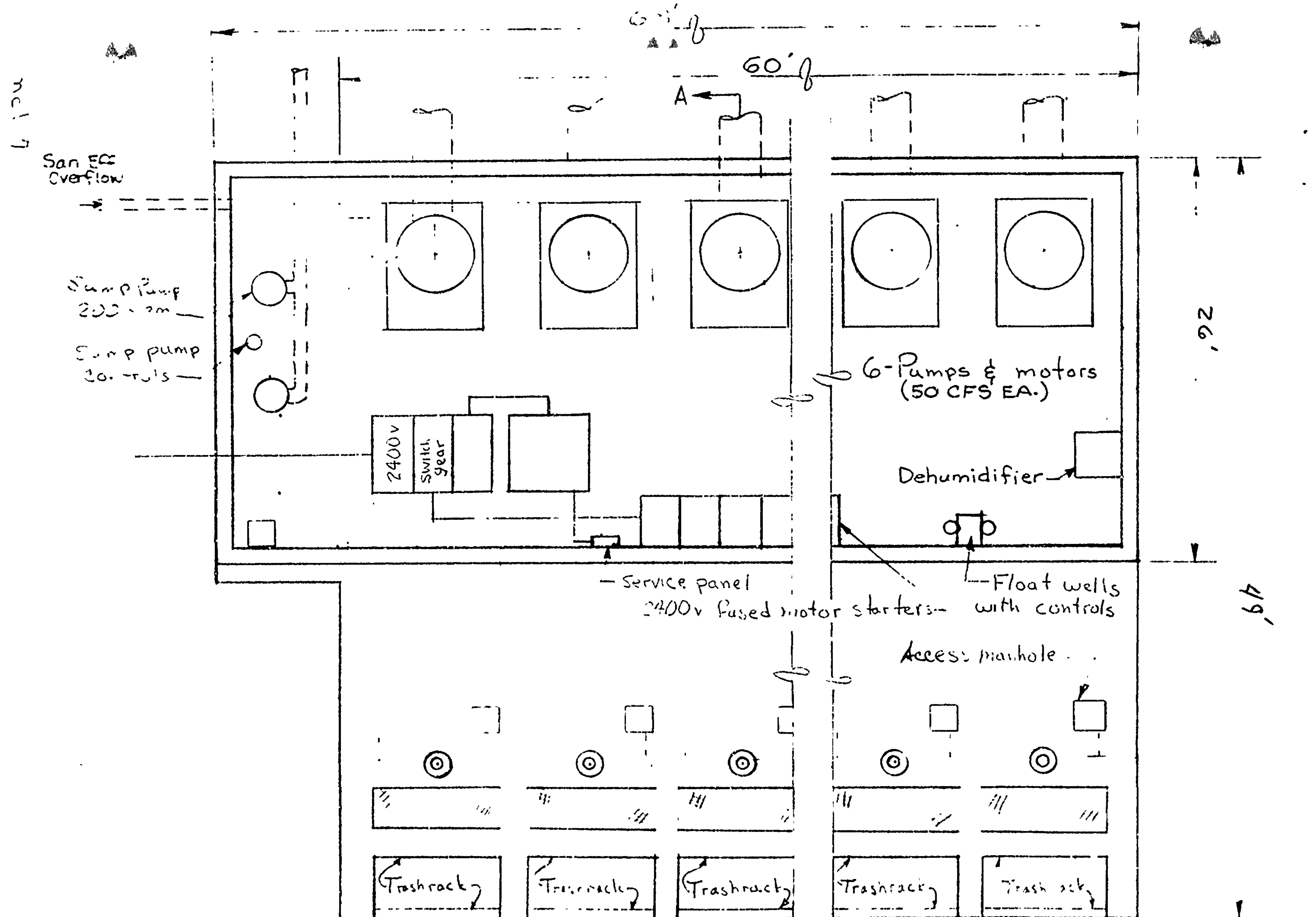

Floodwall T.O.W. El. 303.0
Exist. 10" San.
To be abandoned
Sub-station
Pumping Station
Deck El. 308.
Gravity outfall
Air release & vacuum breaker vault
El. 325.5
El. 320.5
Top of levee Outlet
Grav. Sys.
Sign
ROAD
300
295
290
294.2
292.5
291.3
291.2
292.4
293.2
293.3
292.6
293.6
296.5
296.3
295.2
295.1
298.8
299.2
299.63
294.1
295.3
295.8
297.1
297.2
294.2
BERNVILLE PROT. WORKS
PUMP STA.-SITE PLAN

Incl 6



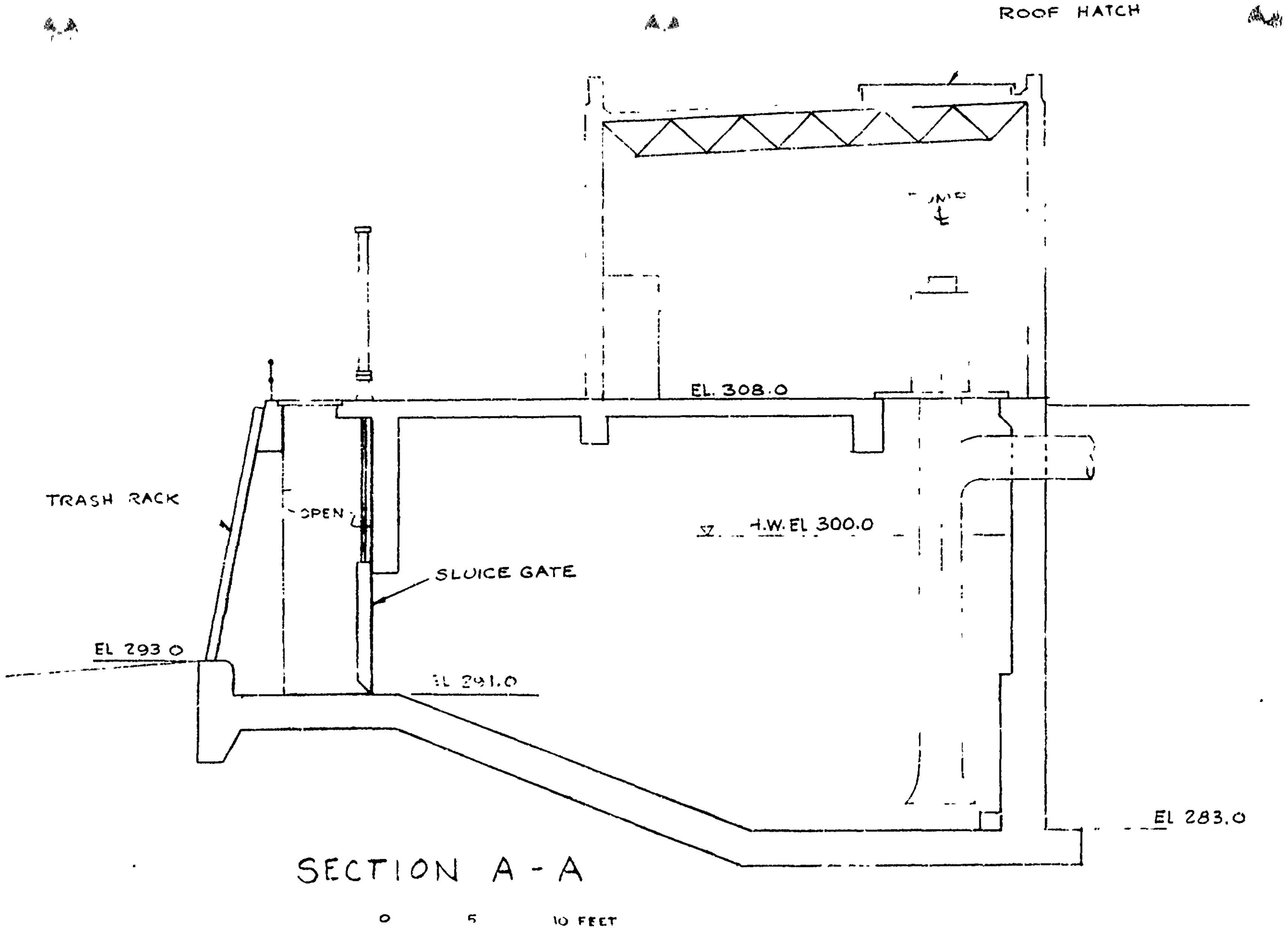
STORM WATER DISCHARGE LINE
PROFILE

BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
PUMP DISCHARGE LINE



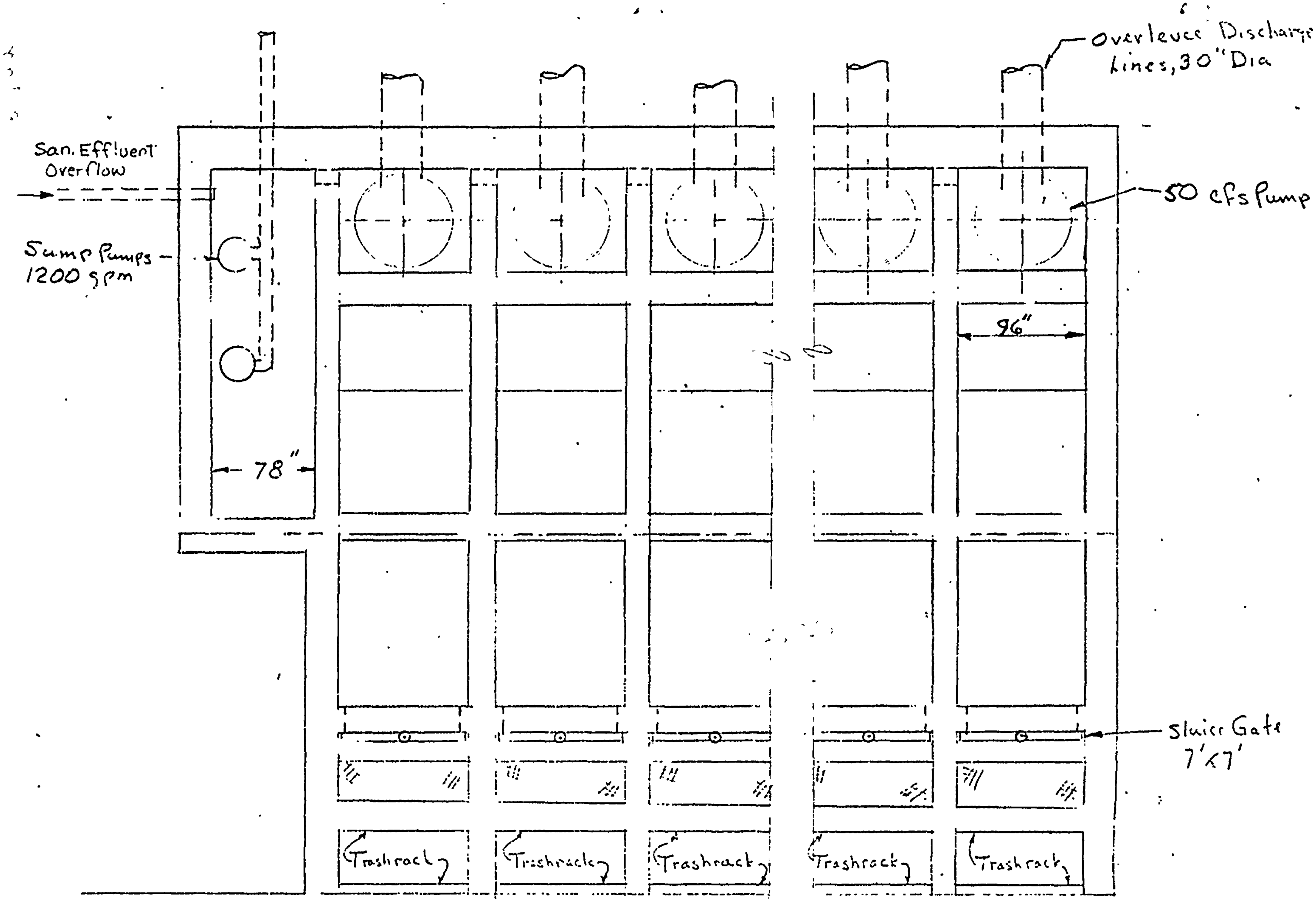
BERNVILLE PROT. WORKS PUMP STATION LAYOUT

Incl 8



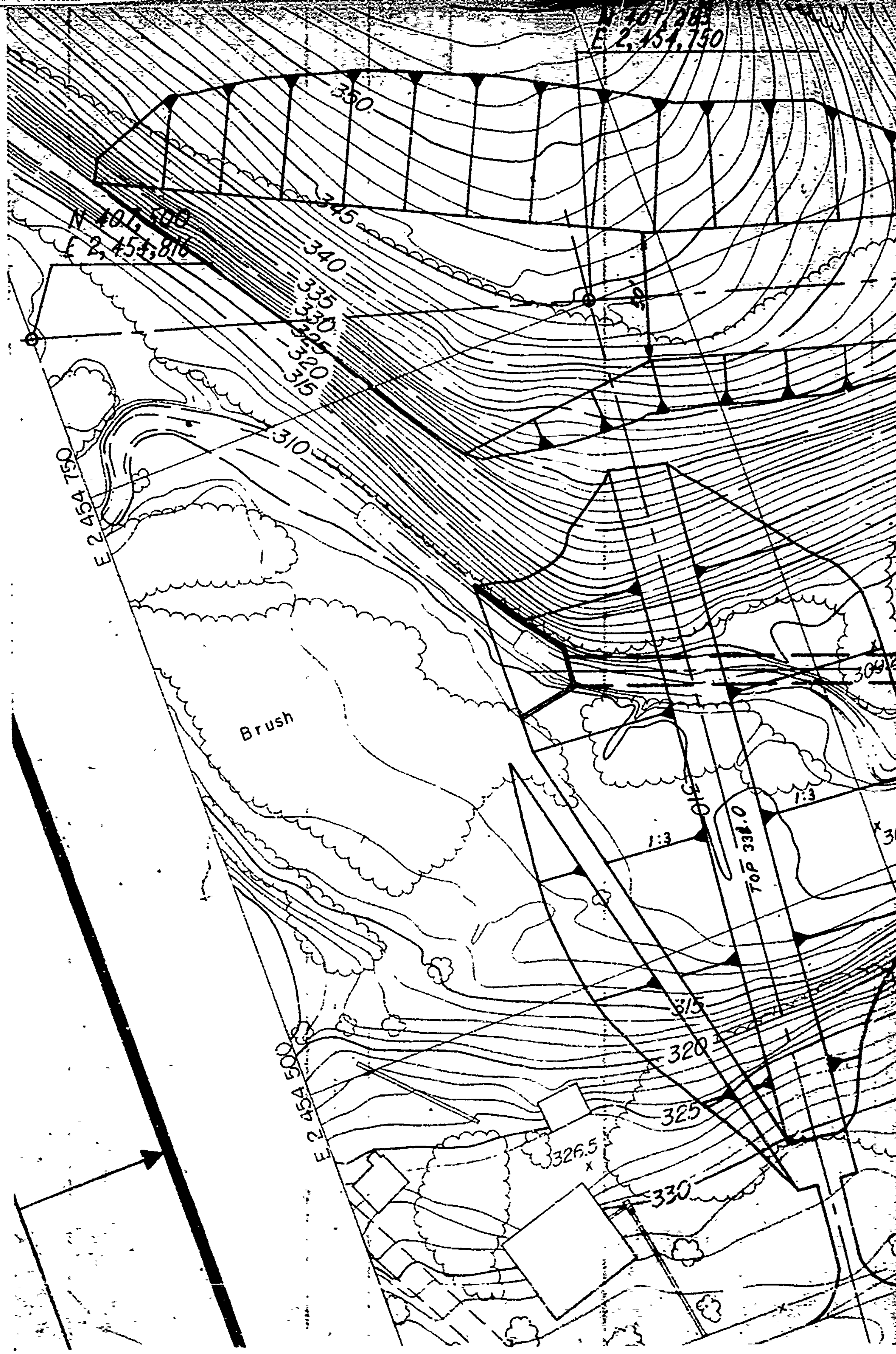
SECTION A - A

BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
PUMP STATION

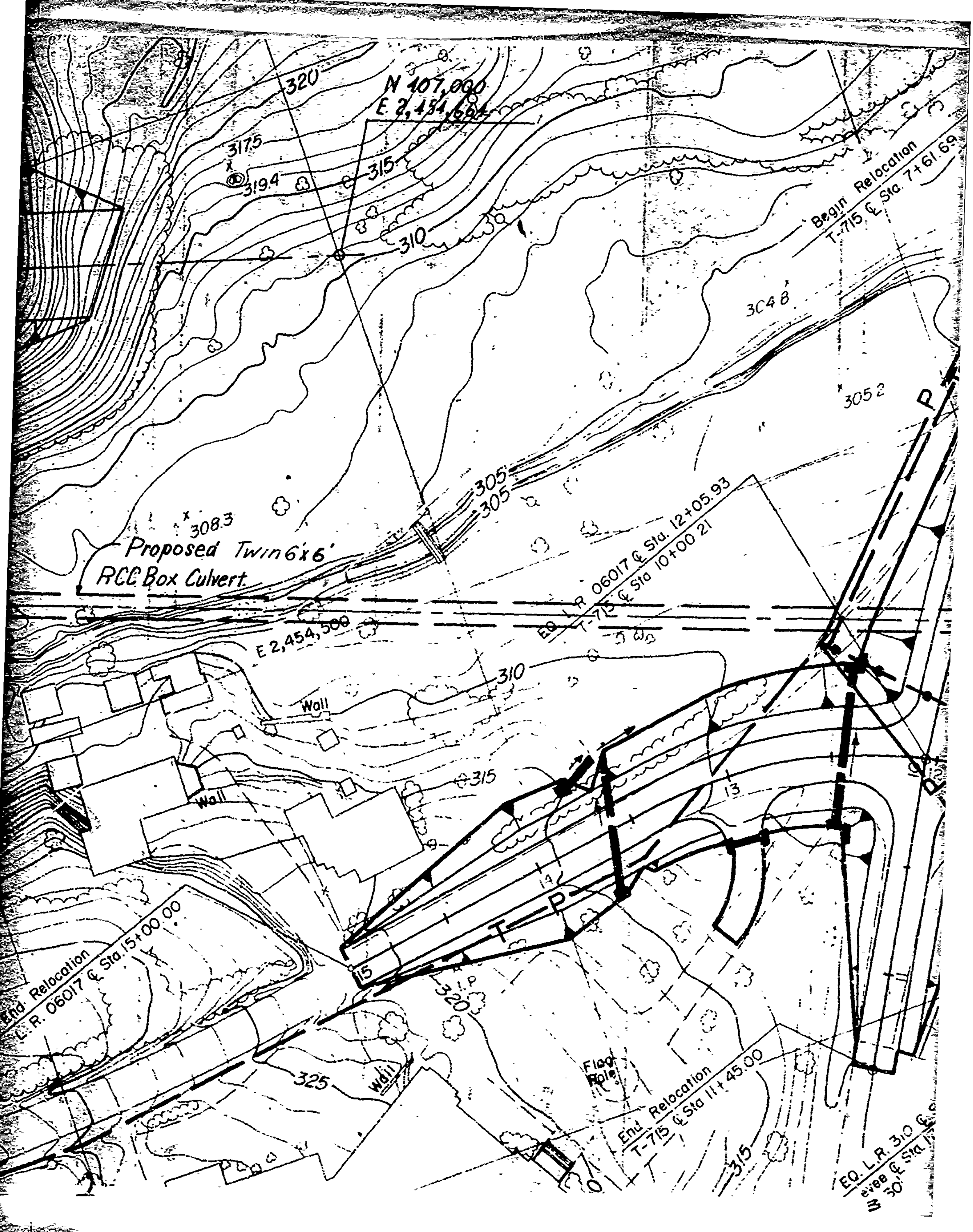


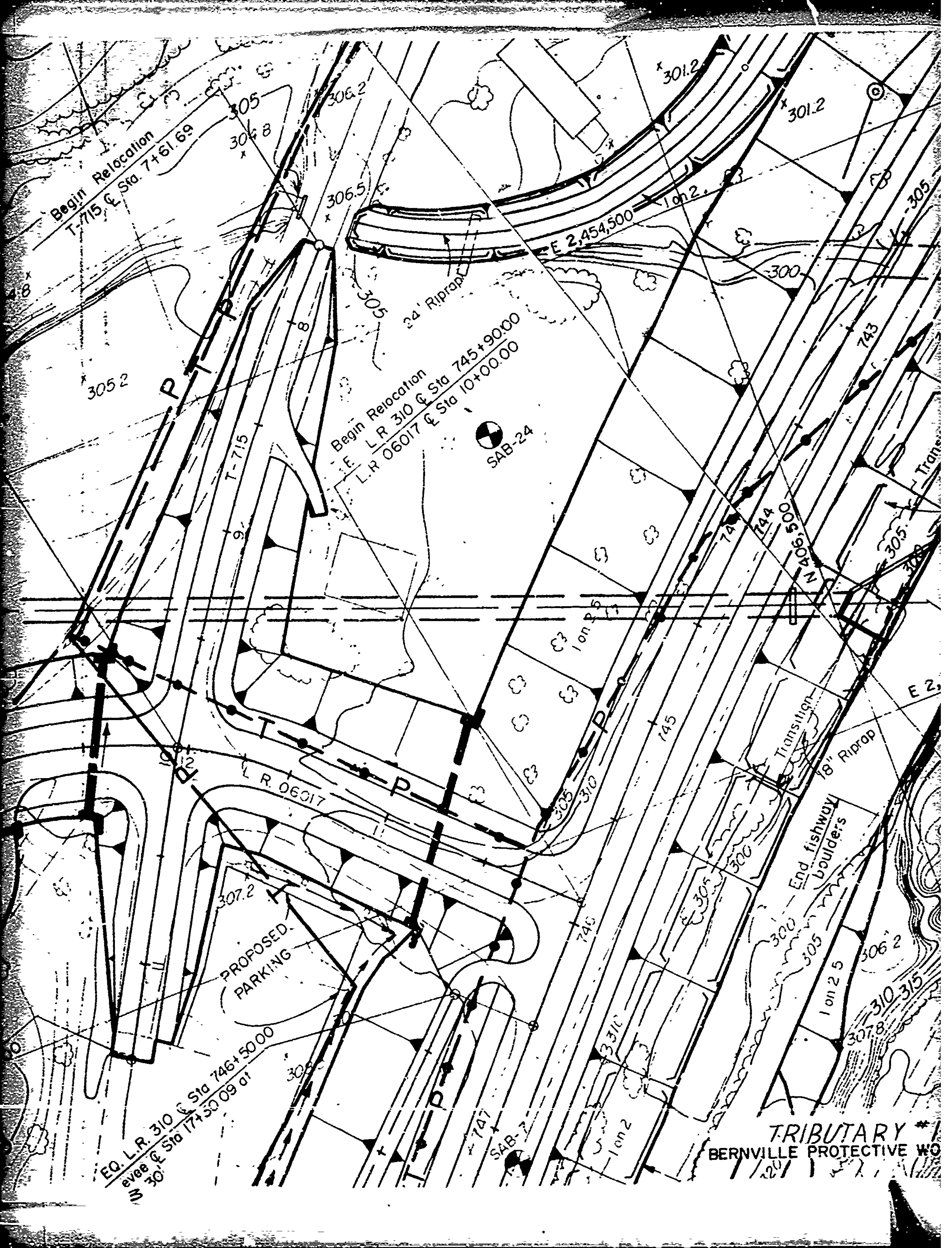
BERNVILLE PROT. WORKS

PUMP STA. SUMP LAYOUT

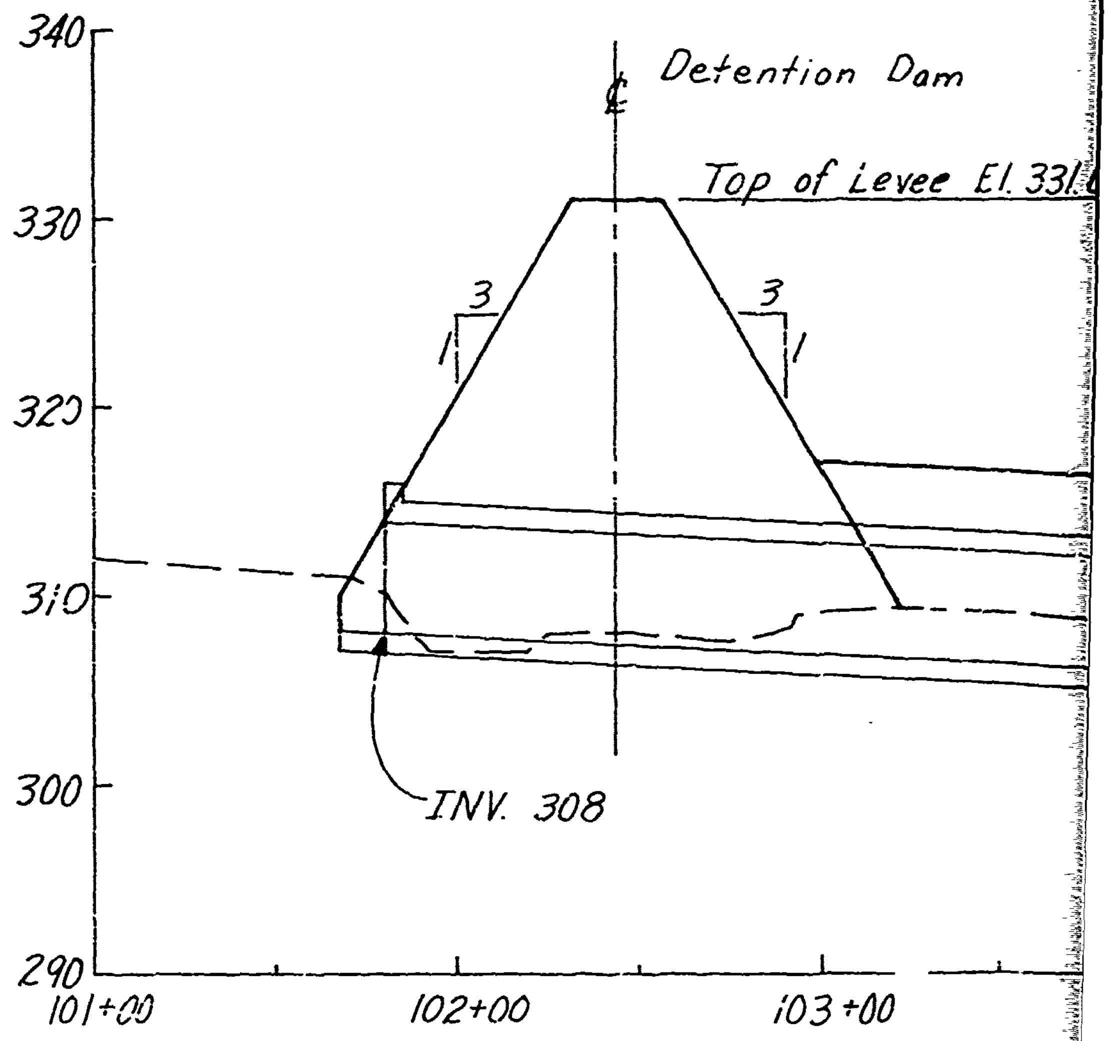

E 2,454,750
350
345
N 401,500
E 2,454,816
340
335
330
325
320
315
310
E 2 454 750
Brush
1:3
1:3
310
315
320
325
326.5
330
E 2 454 500

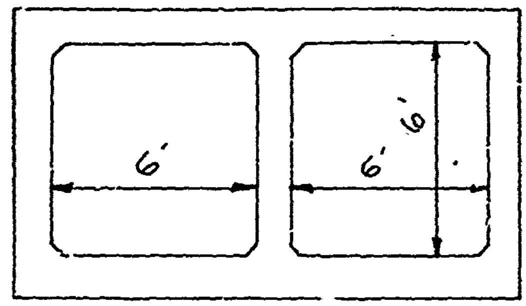
Incl 10


320
N 407,000
317.5
319.4
315
310
Begin Relocation
305.2
305
305
308.3
Proposed Twin 6'x6'
RCC Box Culvert
EQ. L.R. 06017 ℄ Sta. 12+05.93
E 2,454,500
310
Wall
315
Wall
13
14
15
T—P
End Relocation
L.R. 06017 ℄ Sta. 15+00.00
320
325
Wall
Flag Pole
End Relocation
T-715 ℄ Sta 11+45.00
315

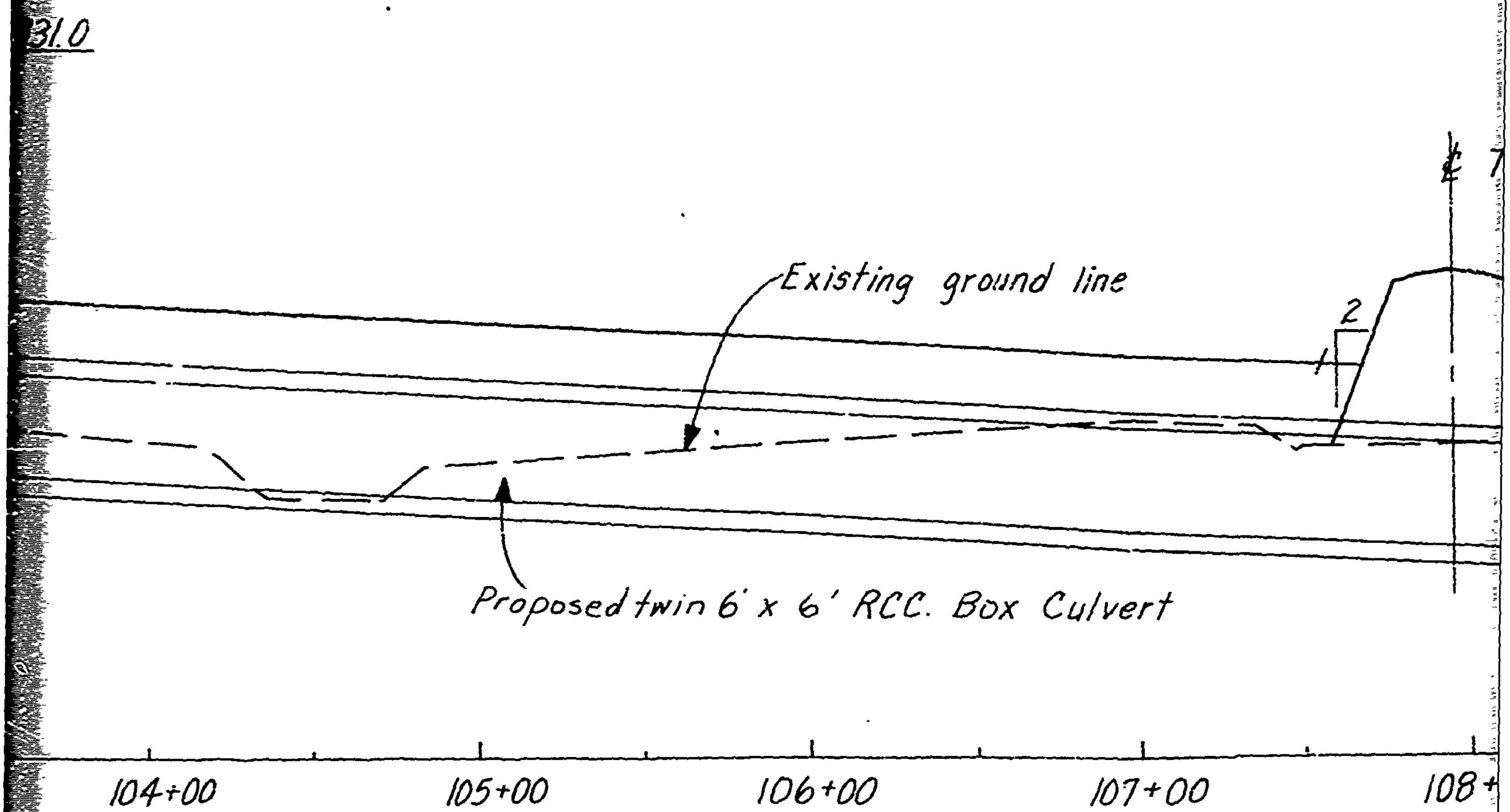


Begin Relocation
T-715 ℄ Sta. 7+61.69
Begin Relocation
℄ L.R. 310 ℄ Sta 745+90.00
L.R. 06017 ℄ Sta 10+00.00
SAB-24
24' Riprap
E 2,454,500
1 on 2
T-715
L.R. 06017
PROPOSED
PARKING
EQ. L.R. 310 ℄ Sta 746+50.00
Levee ℄ Sta 17+30.09 at
Transition
8" Riprap
End fishway boulders
N 406,500
1 on 2.5
SAB-7
TRIBUTARY #1
BERNVILLE PROTECTIVE WO


Detention Dam
Top of Levee El. 331.
3
1
3
1
INV. 308
340
330
320
310
300
290
101+00
102+00
103+00



TYPICAL CONDUIT SECTION



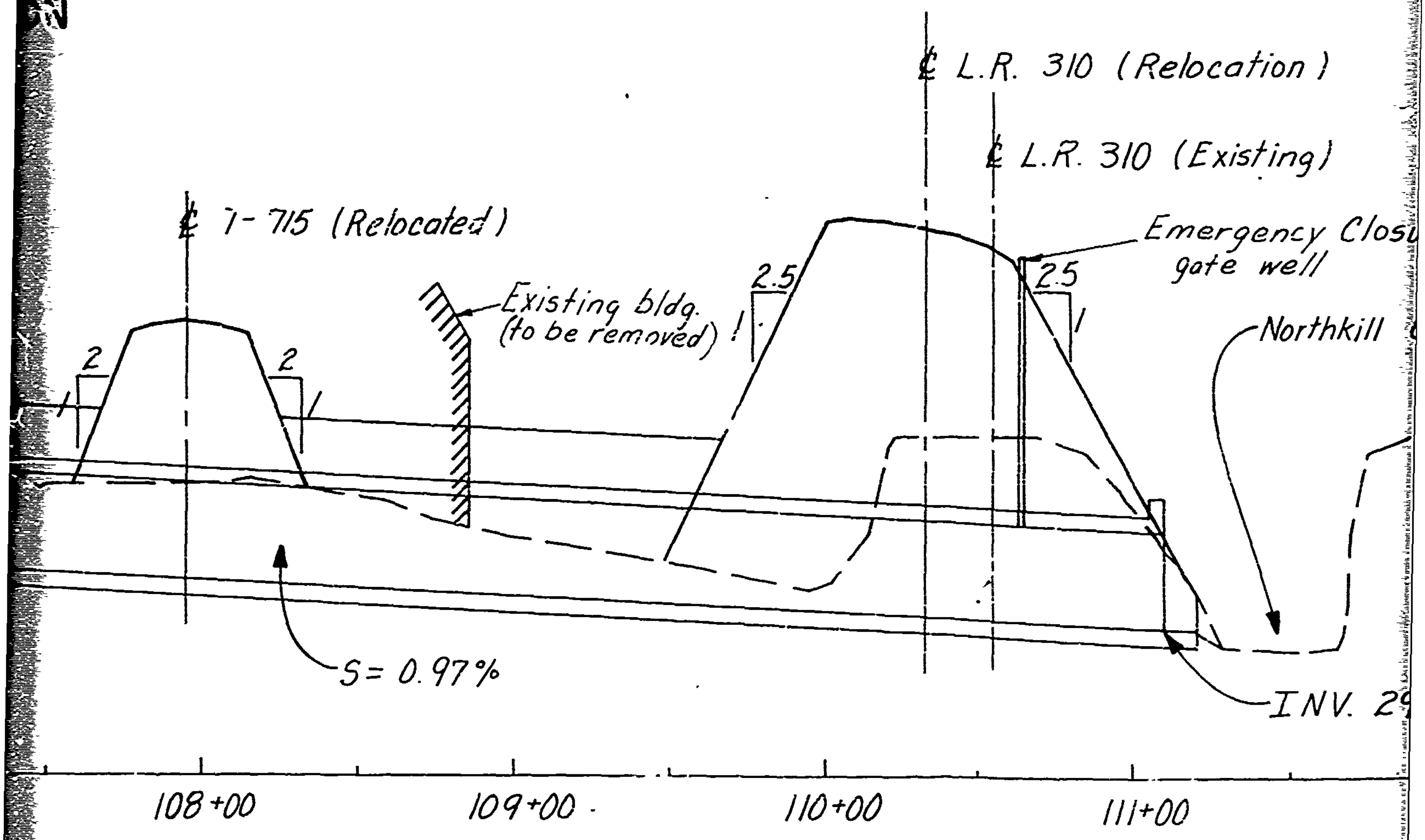
PROFILE ALONG ℄ CONDUIT

TRIBUTARY NO. 1

USCE

Stor
Drain
Peak
Peak

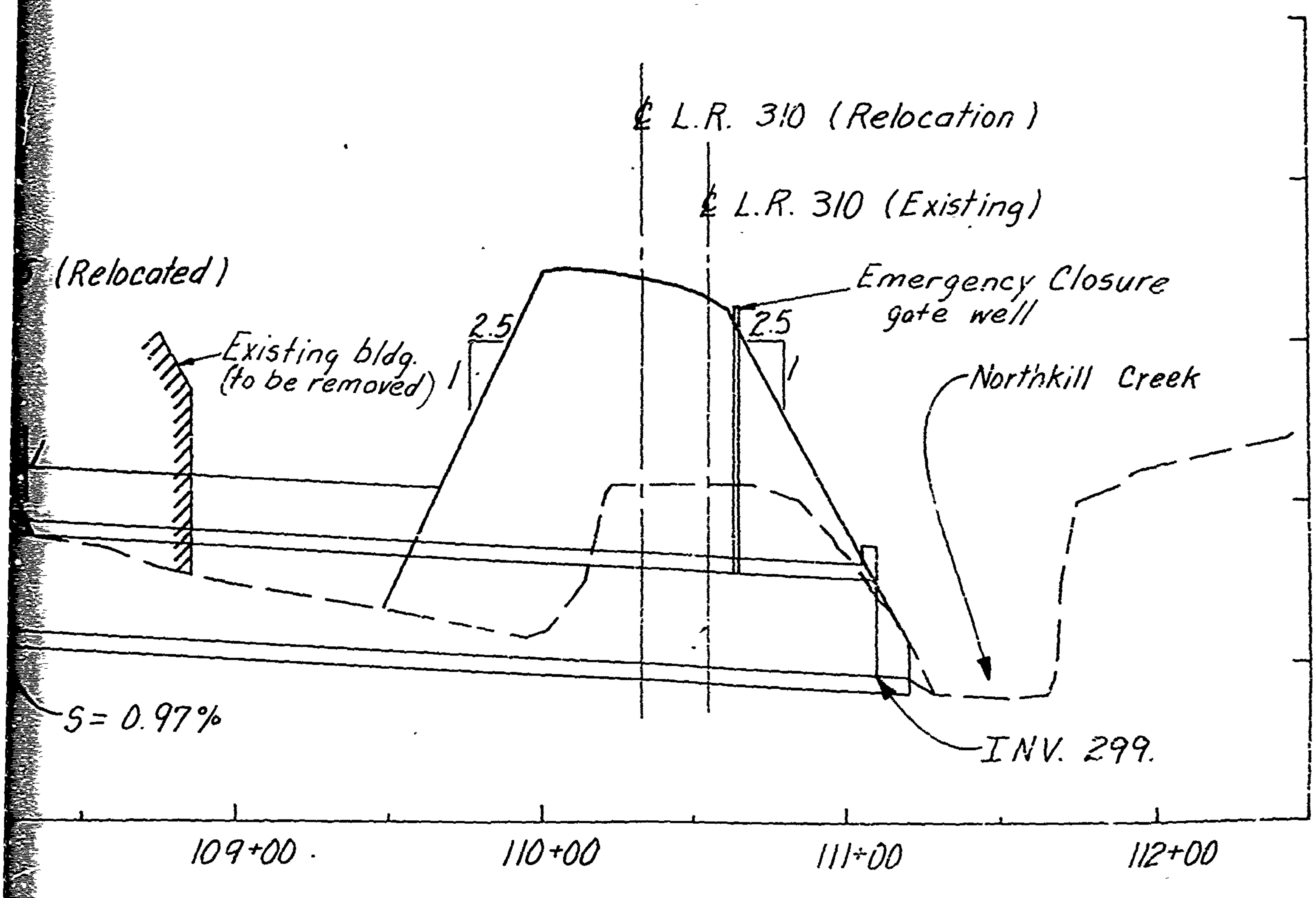
Incl 11



METHOD

USCE (Snyder Synthetic Hydrograph)		PENNDOT
Storm Freq.	Standard Proj. Fld.	50 yr.
Drainage Area	1.14 Sq. Mi	1.14 Sq. Mi.
Peak Q inflow	1052 cfs	Q_{50} = 613 cfs (Rational Metho
Peak Q outflow	965 cfs	as Required by D.M. No. 2.)

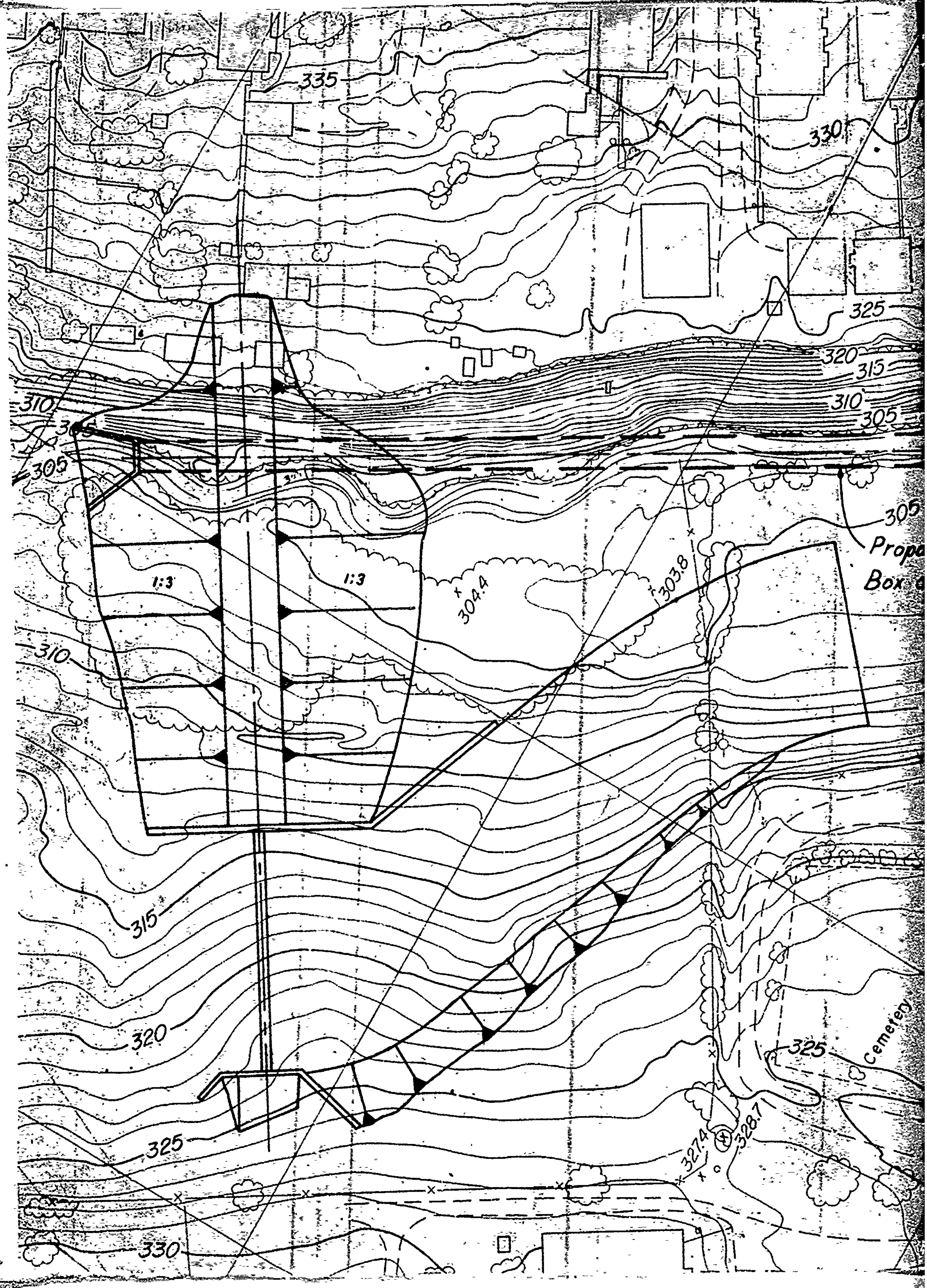
Bernville Pr



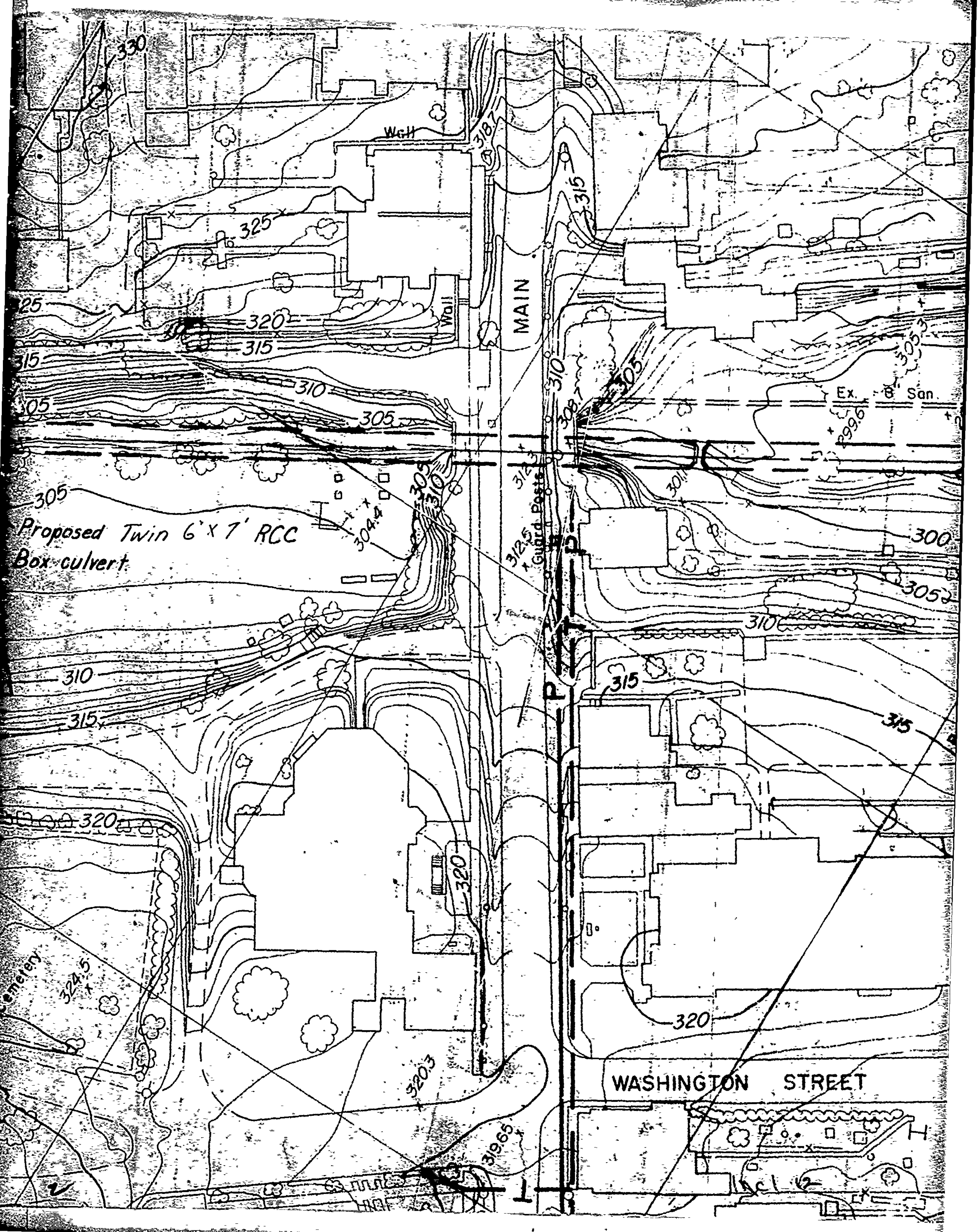
METHOD

...der Synthetic Hydrograph)		PENNDOT
...req.	Standard Proj. Fld.	50 yr
Area	1.14 Sq Mi	1.14 Sq. Mi.
...flow	1052 cfs	Q_{50} = 613 cfs (Rational Method as Required by D.M. No. 2.)
...tflow	965 cfs	

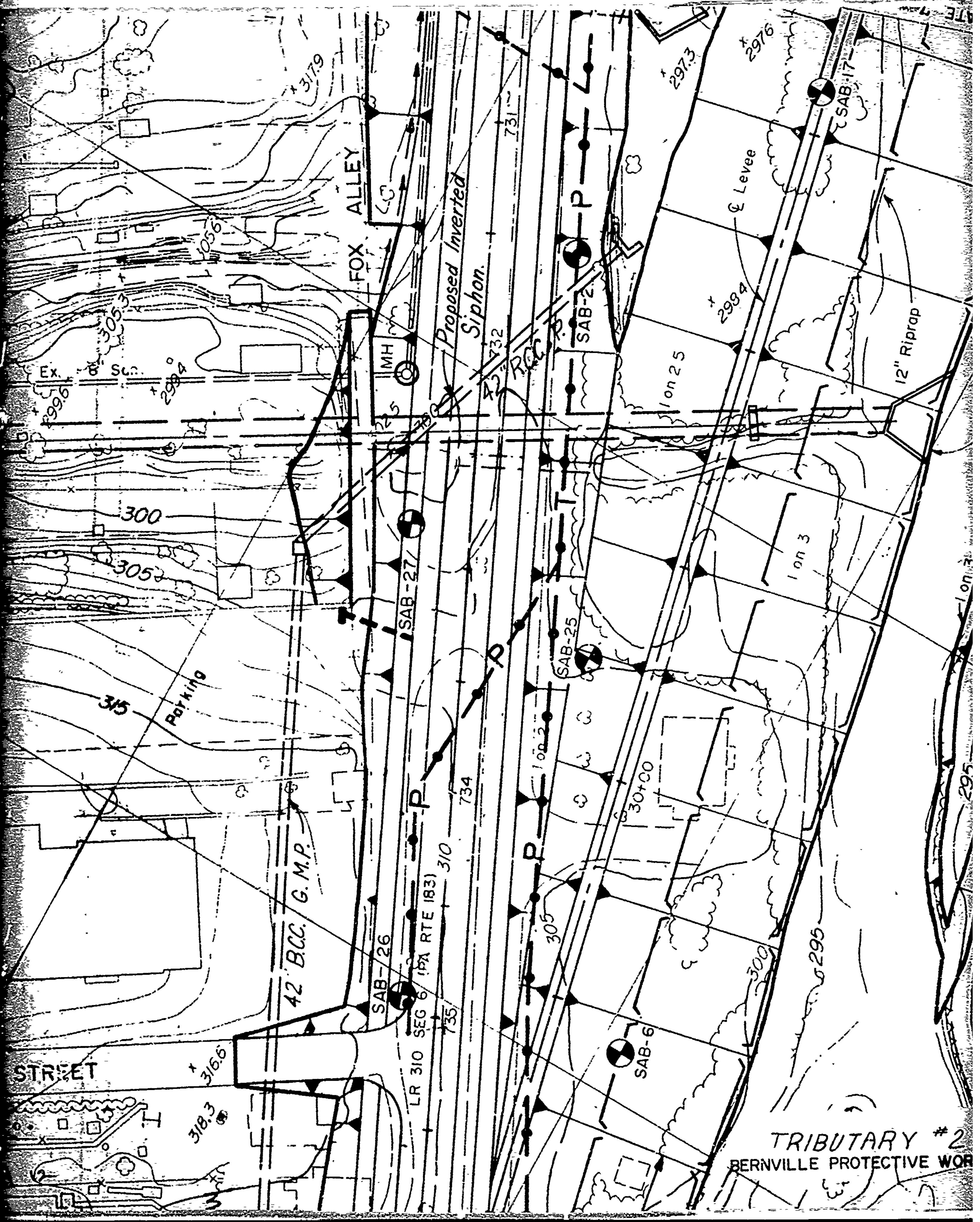
Bernville Protective Works

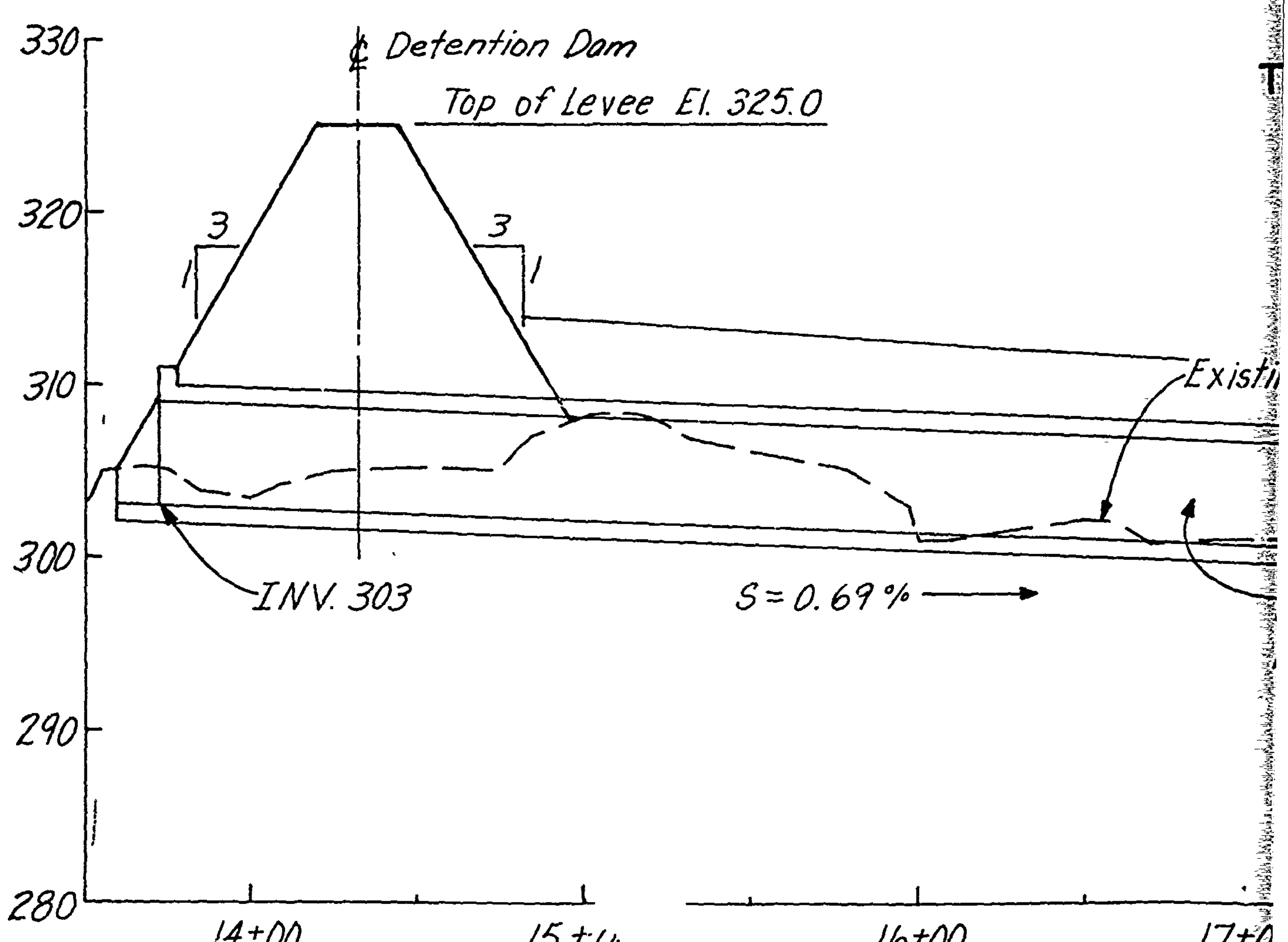


335
330
325
320
315
310
305
305
Propo
Box
1:3
1:3
304.4
303.8
310
315
320
325
325
Cemetery
327.4
328.7
330



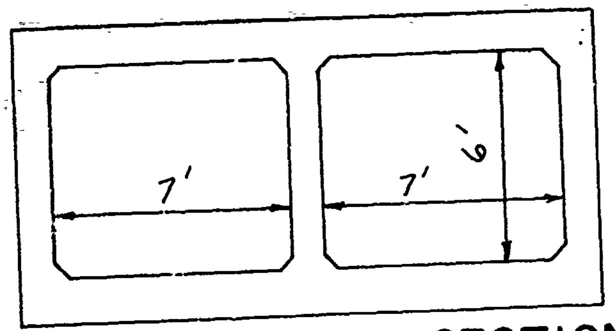
MAIN
WASHINGTON STREET
Proposed Twin 6'x7' RCC
Box culvert
Wall
Wall
Guard Posts
Ex. 8" San.
Cemetery
330
325
320
315
310
305
300
318.7
308.7
312.5
304.4
301.1
299.6
305.3
324.5
320.3
319.65


FOX ALLEY
Proposed Inverted Siphon
42" R.C.P.
MH
Ex. 8" San.
SAB-27
SAB-26
SAB-25
SAB-6
SAB-17
℄ Levee
12" Riprap
1 on 25
1 on 3
1 on 2
30+00
42" B.C.C. G.M.P.
LR 310 SEG 6 (PA RTE 183)
Parking
STREET
300
305
315
295
316.6
318.3
297.3
297.6
298.4
TRIBUTARY #2
BERNVILLE PROTECTIVE WOR

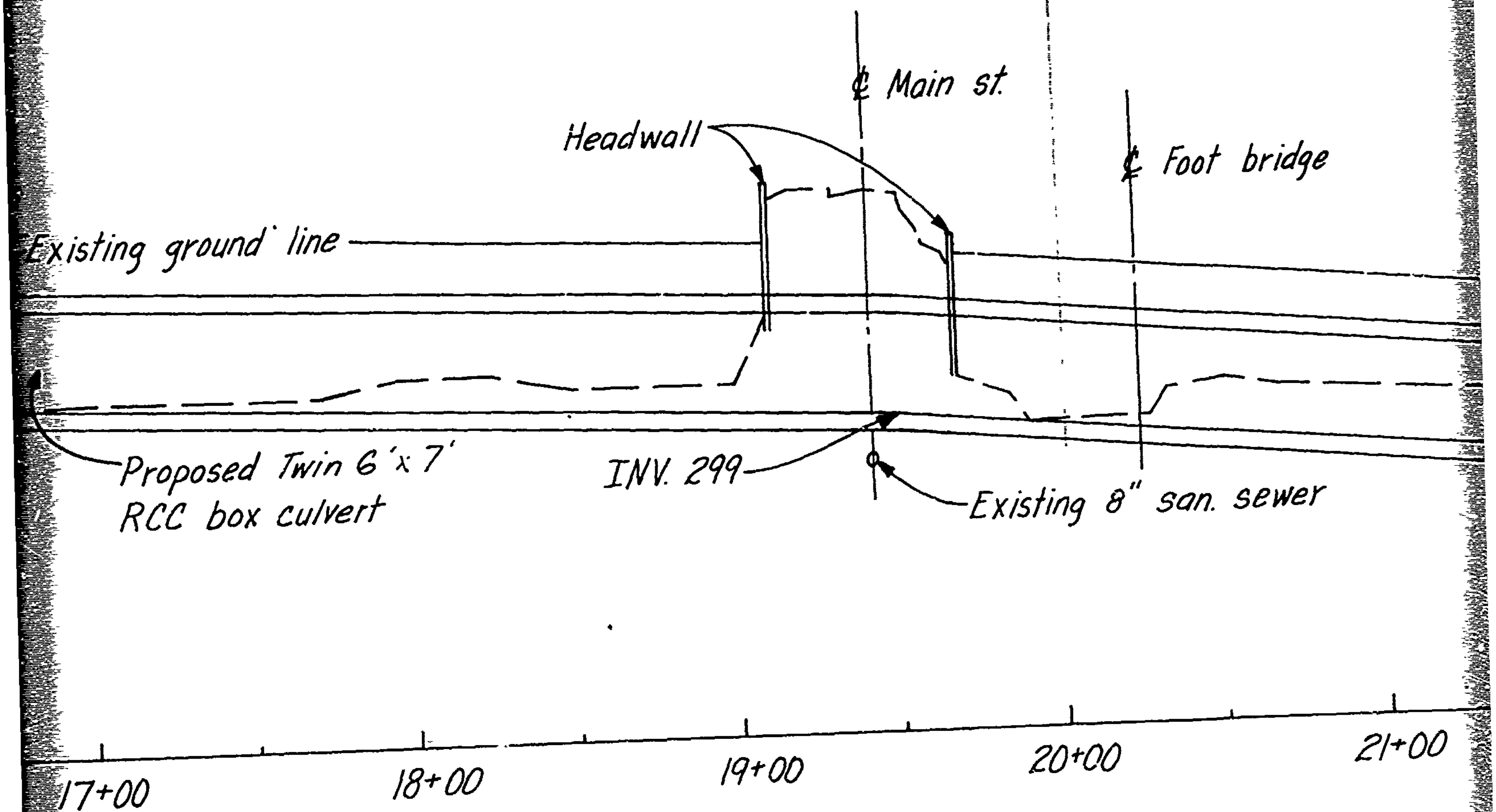


℄ Detention Dam
Top of Levee El. 325.0
3
1
3
1
Existi
INV. 303
S = 0.69 %
330
320
310
300
290
280
14+00
15+00
16+00
17+0

Incl 13

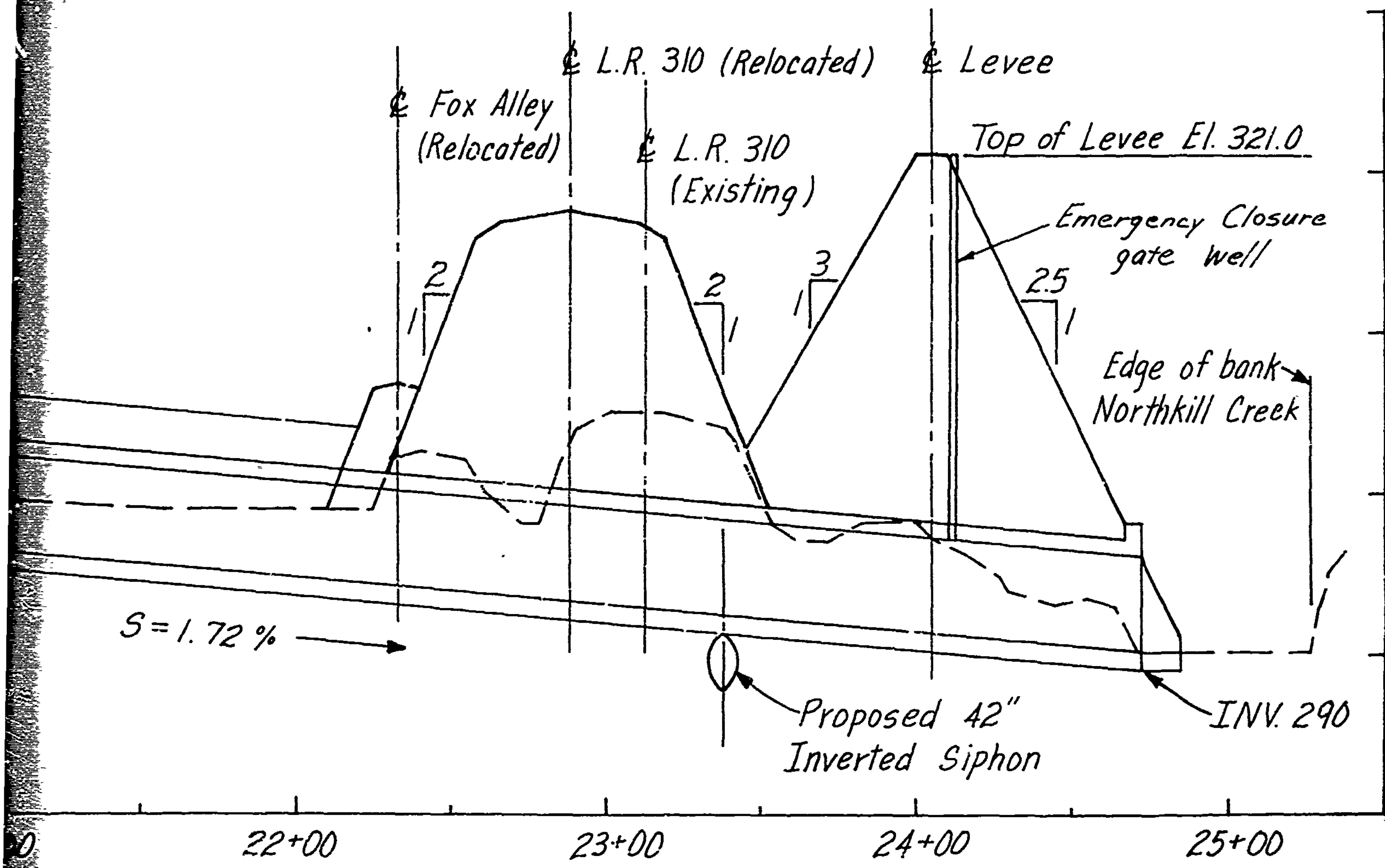


TYPICAL CONDUIT SECTION



PROFILE ALONG ℄ CONDUIT

TRIBUTARY NO.2



METHOD

USCE (Snyder Synthetic Hydrograph)

Storm Freq.	Standard Proj. Fld.
Drainage Area	.89 Sq. Mi.
Peak Q inflow	900 cfs
Peak Q outflow	755 cfs

PENNDOT

Q_{50} = 580 cfs (Rational Method as Required by D.M. No.2.)

Bernville Protective Works

NAPEN-H 5 June 1975

SUBJECT: Bernville Interior Drainage Hydrology & Hydraulics

1. Methodology

a. Hydrology- Standard Project Floods and 10 year, 50 year and 100 year floods were developed for interior drainage Tributaries 1, 2 & 3. The Standard Project Flood hydrographs were developed by determining the runoff from each tributary during the occurrence of an SPF event generally centered over Bernville. (This is the same centering used in determining the SPF for the Blue Marsh Dam). The frequency floods (10-50-100 year) were developed from frequency precipitation as presented in U. S. Weather Bureau Technical Paper No. 40.

b. Detention Dams- Dams proposed on Tributaries 1 and 2 were designed to detain flood peaks and pass flows directly through pressure conduits into Northkill Creek. Spillways for these projects were sized by routing the SPF through each with the pressure conduit assumed blocked. These routings developed the maximum water surface level in each pool for various sized spillways. Freeboard allowances were added to the water surface elevation to determine the top of dam elevation. To determine the effect of the proposed dams and spillways (Tributaries 1 and 2) on a Spillway Design Flood, the SDF was routed through the reservoirs with the pressure conduits assumed unobstructed. The SDF was approximated by doubling the SPF and therefore is essentially equal to a probable maximum flood. The resulting routings indicate that the maximum pool levels would be 328.6 ft. SLD (vs. 328.4' for the SPF routing with the conduit blocked) for Tributary #1 and 322.2 ft SLD for Triburary #2 (vs. 321.9' for the SPF with conduit blocked routing).

c. Pressure Conduits- Pressure conduits were designed for each dam. They were sized to keep the SPF and the frequency floods below the proposed spillway crest elevation. SPF routings used in sizing the pressure conduits were done with coincident SPF elevations on the Northkill Creek. The Northkill SPF was assumed coincident with a Blue Marsh Lake elevation at Spillway Crest (Elevation 307.0).

d. Ponding Area Pump Sizing- Pump capacity was initially sized to pass an SPF event through the ponding area without exceeding the non-damage elevation of 300.0 ft. with the same coincidental Northkill Creek stages as indicated in Para. 2 "Pressure Conduits". Additional data for other ponding area elevations and other coincidental conditions on the Northkill Creek were investigated. These are discussed below in Para. 2c. Variation of particular pump sizes and total pump capacity required is discussed in Para. 2-d.

e. Gravity Outlets- The gravity conduits were originally designed to pass a 10 year inflow without pumping, but upon further study it became apparent that the gravity outfalls were virtually independent of pumping plant capacity. The reasons were as follows:

a. With the design SPF event, the elevation on the Northkill Creek is greater than the allowable interior ponding elevation causing an adverse head

Incl 4

condition. Increasing the size of the gravity outfall under this condition is of no particular benefit.

b. The controlling elevations for starting the pumps were established by the SPF event. In evaluating frequency events of smaller magnitude than the SPF, it becomes apparent that a large interior head cannot occur since pumping initiates at an approximate interior ponding depth of 3.5 feet. Any increase in conduit size yields negligible hydraulic benefits.

c. In developing coincidental conditions for the Northkill River stages for events of lesser magnitude than the SPF, the differential head was not great enough to warrant large gravity outfalls. For example, the Northkill river elevation for a 10 year frequency pool was established at elevation 298. Considering the allowable peak interior elevation is 300.0 the resulting head differential is minimal.

Because of these considerations, criteria for sizing of gravity outfalls shifted from performance to practial limitations. Flap-gates are practical for 4 foot diameter pipes and reasonably economical to construct. Two-four foot outfalls will pass 120 cfs or approximately an annual event storm with conditions on the Northkill being favorable.

2. Results

a. Area 1- The detention dam on Area 1 Tributary formerly referred to as structure‡B is located as shown on Inclosure 1. The capacity at the crest is 32 acre-ft. The spillway is a 50 ft. side channel with a crest elevation of 325'. Routing an SPF through the spillway with the outlet conduit blocked yielded a water surface elevation of 328.4. An addition of a free board allowance established the top of dam at elevation 331. The pressure conduit size was determined as two 6 x 6' conduits. Routing of SPF and SDF through the detention dam resulted in water surface elevations of 324.6' and 328.6' and are shown on plates 2 & 3 respectively. Average conduit velocities for the SDP and SPF were 14.7 fps and 13.0 fps. respectively.

b. Area 2- The detention dam on Area 2 tributary, formerly referred to as Structure 2A-1 is located as shown on Inclosure 1. The capacity at the spillway crest is 44 acre ft. The spillway is a 100 ft. concrete notch with a crest elevation of 320.0'. Routing an SPF through the spillway with the outlet conduit block yielded a water surface elevation fo 321.9'. The addition of a free board allowance established the top of dam at elevation 325. The pressure conduit size was determined as two 6' x 7' conduits. Routing an SPF and SDF through the detention dam resulted in water surface elevations of 319.7' and 322.2' and are shown on plates 4 & 5 respectively. Average conduit velocities for the SPF and SDF were 9.0 fps and 9.6 fps respectively.

c. Area 3- The third tributary flows directly into the ponding area and runoff is removed by pumping when high flow occurs on the Northkill Creek. Two cases were investigated. The first case placed an SPF flow on the Northkill Creek with a coincident Blue Marsh Lake elevation of 307.0' (spillway crest). The second case placed an SPF flow on the Northkill Creek with coincidental Blue Marsh Lake elevation of 290.0' (summer conservation pool). Both cases placed the first 50 cfs pump on line at a ponding elevation 295.4". This elevation was adopted as the minimum elevation required to pass low (high frequency) flows and yet would initiate pumping early enough to minimize total pumping capacity requir to pass the design SPF flow. Additional 50 cfs pumps were placed on line in stage increments equivalent to 4.13 acre-ft. of ponding volume. This pattern was adopted to maintain a minimum of one hour run time once each pump wasplaced on line. Table 1 lists the pumping requirements to maintain various ponding elevations for both cases. It should be noted that the pumping requirements remained the same for both cases. Only when pumps are placed on line at higher elevations will a differential head develop for the coincidental 290'-SPF on the Northkill Creek. Essentially for both cases the gravity outfalls will remain blocked when pumps are placed on line before elevation 296.5'. Plates 6 and 7 are included to demonstrate the routing curves, and represent case 1 and 2 respectively. Gravity outfalls were sized as two 4' ft. diameter pipes. An increase in gravity conduit size was judged unnecessary due to reasons listed in Para. 14 above.

d. Alternate pump sizes for Area 3- Performance curves were also developed for 75 cfs unit pumps and 100 cfs unit pumps. The results were essentially identical with the 50 cfs unit pumps. Therefore, by hydraulic considerations the total pump capacity is the primary concern, with the effect of individual pumps sizes being negligible in the 50-100 cfs per unit range. This equivalency is not true from mechanical considerations.

Increasing the size of the pumps from 50 cfs to 100 cfs would:

1. Increase the sump width from 90 inches to 170 inches.

2. Increase the sump depth by 95 inches.

3. Increase the sump length from 225 inches to 450 inches.

4. Decrease the total station width by 4.5 feet.

The overall effect would be an increase of eight feet in the sump depth, an increase of nineteen feet in station length and a decrease of four and a half feet in station width. See Plates 8 & 9. These changes would result in an overall increase in sump station cost.

NAPEN-H

The price of a 50 cfs pump is approximately half the price of a 100 cfs pump, resulting in a negligible price difference for the pumps. The larger pumps would require larger sluice gates and trash racks. The larger pumps would start at approximately the same elevation as the smaller pumps, but one 100 cfs pump starting would increase the electrical demand factor more substantially than the starting of a 50 cfs pump. This demand charge carries its effects over the eleven month period following the actual pump start. In addition, if diesel power would prove to be most economical for the 100 cfs pumps, a larger station house would be required to house the diesel power plants.

Table 1-Pump requirements to maintain various ponding elevations.

a. The flow on the Northkill Creek is an SPF with a coincidental Blue Marsh Lake at elevation 307 (Spillway Crest)

b. First pump placed on line at Elevation 295.4

Allowable Ponding Elevation	No. & Size of Pumps (Nearest 50 cfs)	Computed Elevation Obtained
300.0	6- 50 cfs	299.65
301.0	5- 50 cfs	300.59
302.0	4- 50 cfs	301.80
303.0	3- 50 cfs *	303*

*Estimated

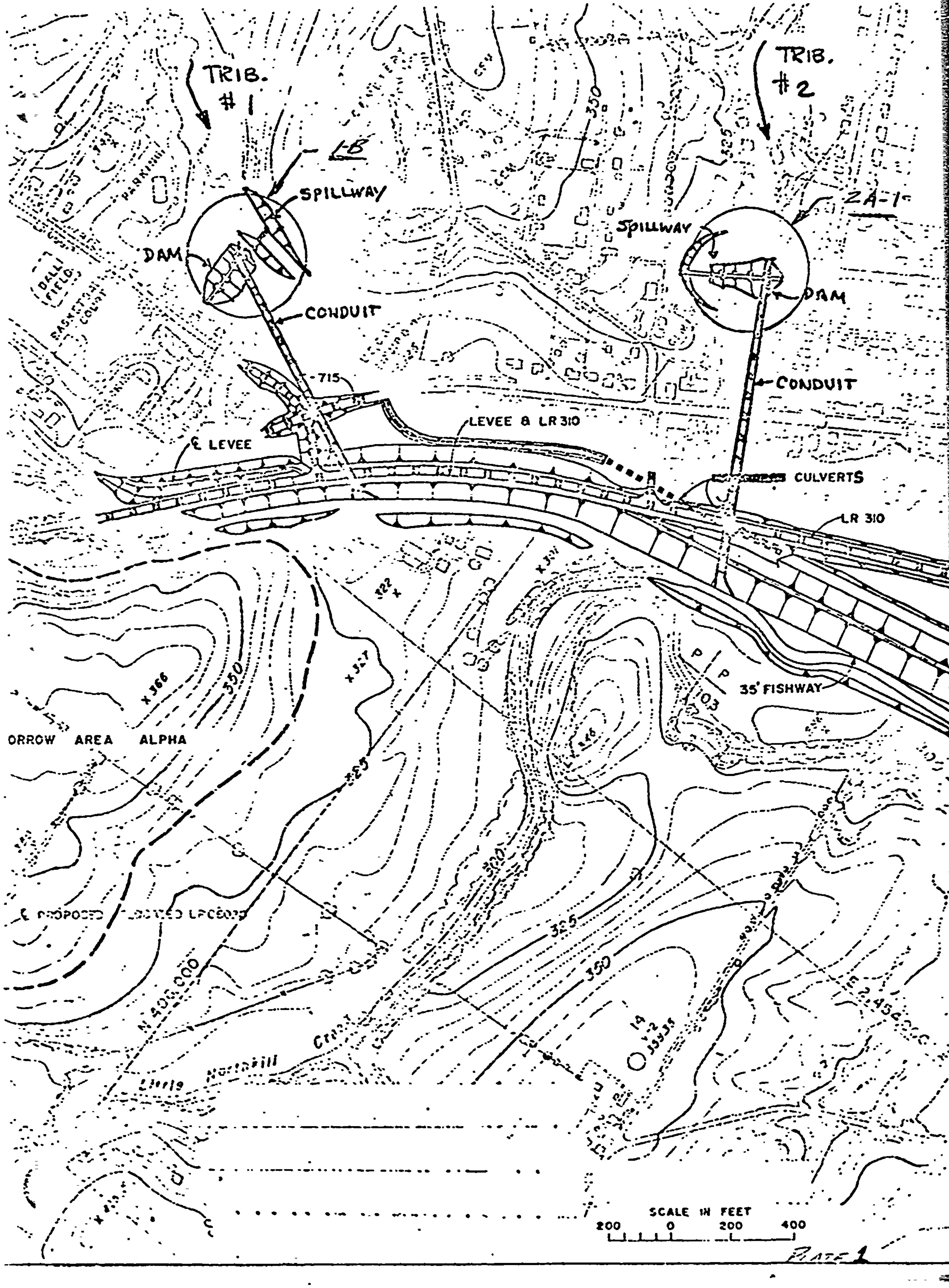
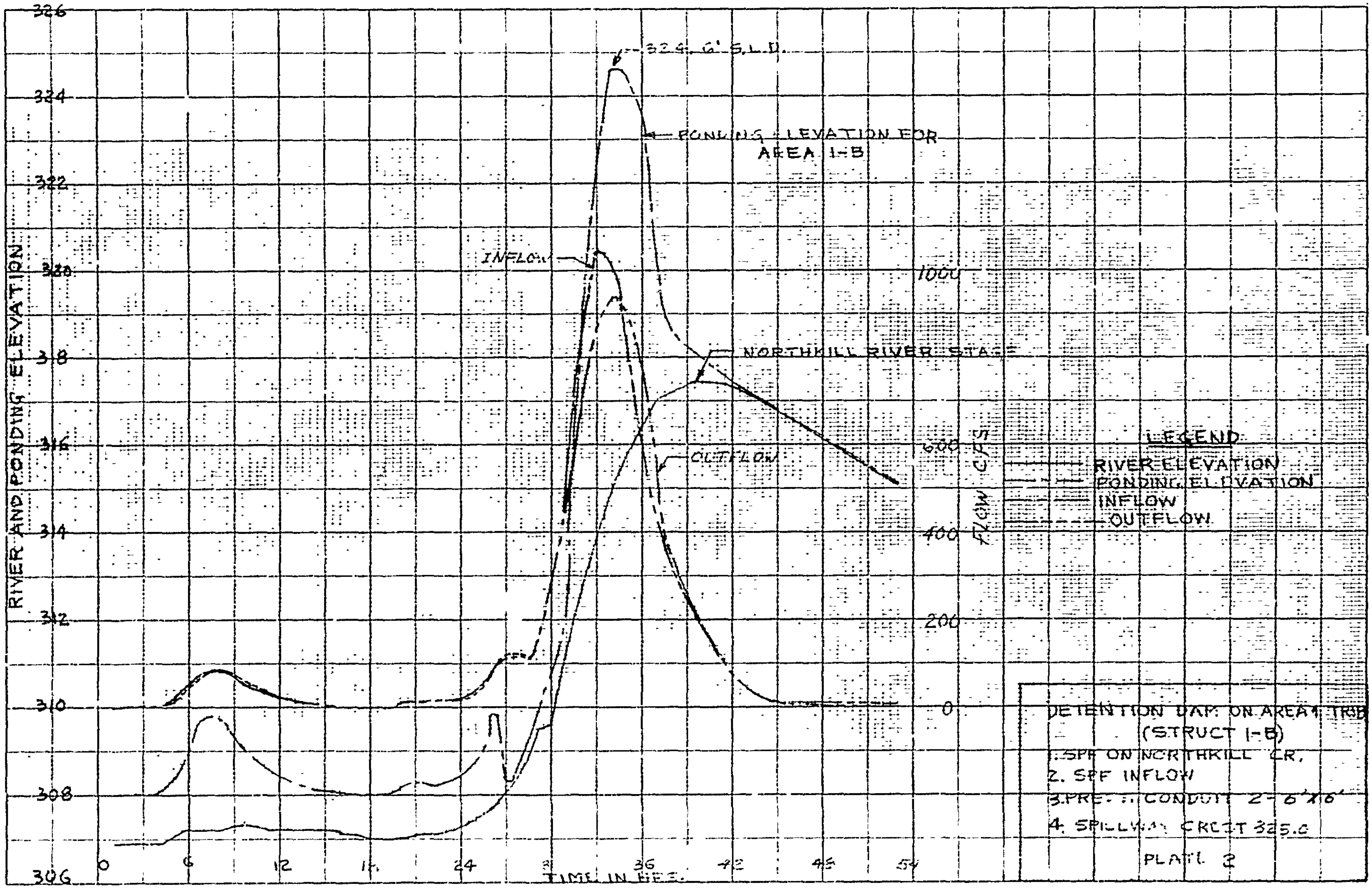
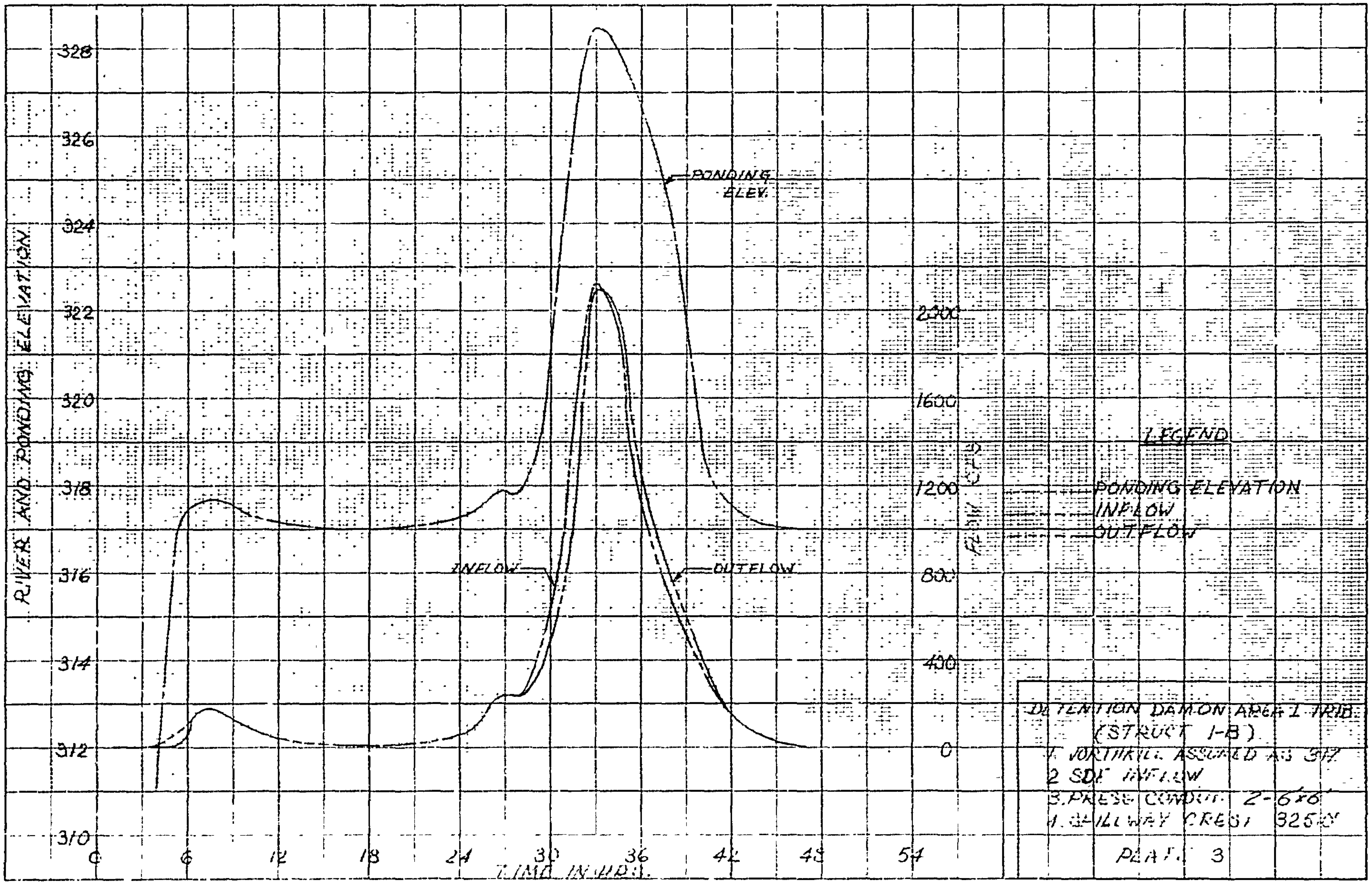
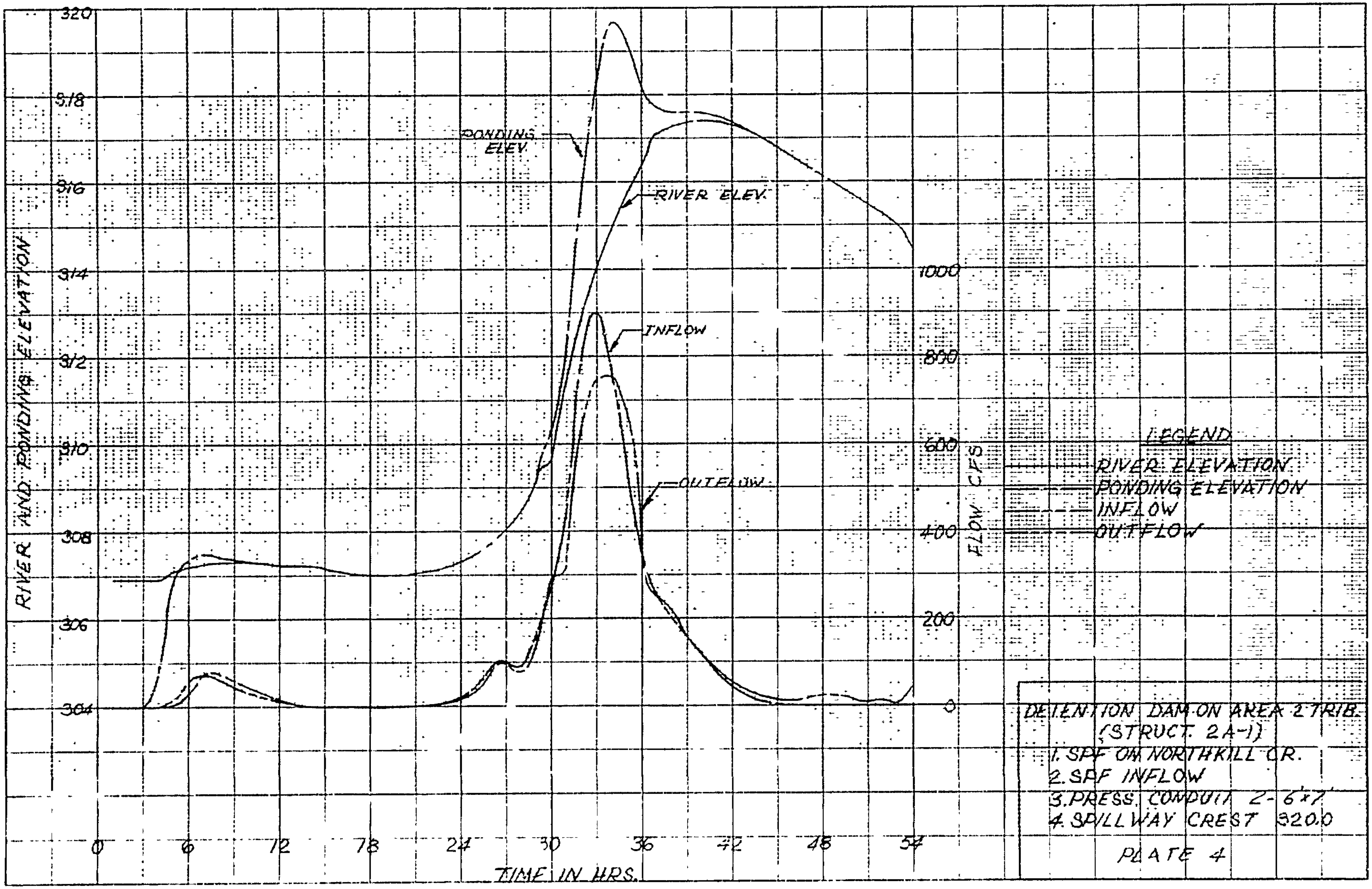

TRIB. #1
SPILLWAY
DAM
CONDUIT
TRIB. #2
2A-1
SPILLWAY
DAM
CONDUIT
715
LEVEE & LR 310
℄ LEVEE
CULVERTS
LR 310
35' FISHWAY
ORROW AREA ALPHA
350
325
SCALE IN FEET
200 0 200 400

PLATE 1



324.6' S.L.D.
PONDING LEVATION FOR AREA 1-B
INFLOW
NORTHKILL RIVER STAGE
OUTFLOW
LEGEND
RIVER ELEVATION
PONDING ELEVATION
INFLOW
OUTFLOW
RIVER AND PONDING ELEVATION
FLOW CFS
TIME IN HRS.
DETENTION DAM ON AREA 1 TRIB
(STRUCT 1-B)
1. SPF ON NORTHKILL CR.
2. SPF INFLOW
3. PRE. CONDUIT 2-6'x6'
4. SPILLWAY CREST 325.0
PLATE 2

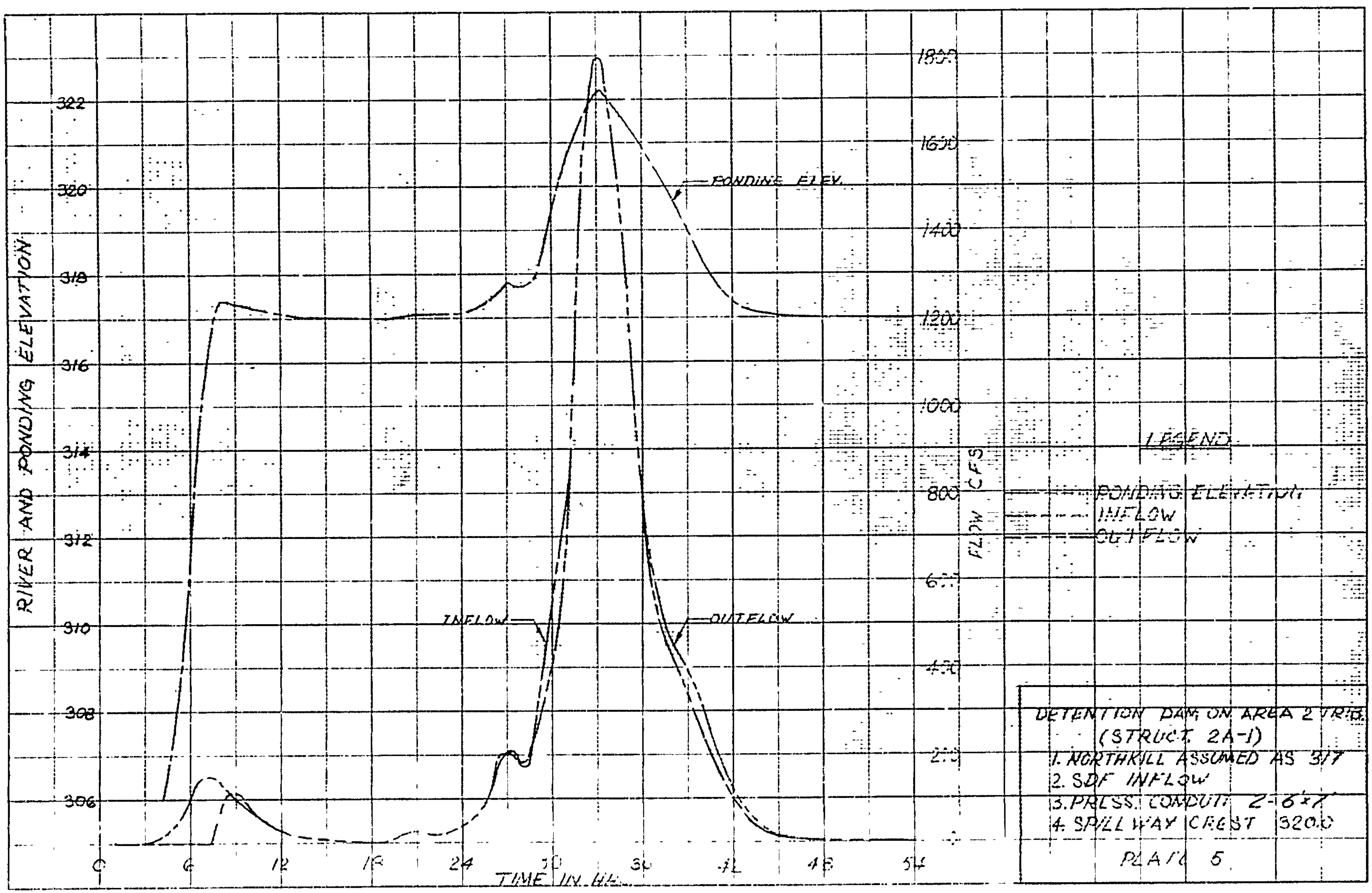

RIVER AND PONDING ELEVATION
328
326
324
322
320
318
316
314
312
310
0
6
12
18
24
30
36
42
48
54
TIME IN HRS.
FLOW CFS
2000
1600
1200
800
400
0
PONDING ELEV.
INFLOW
OUTFLOW
LEGEND
PONDING ELEVATION
INFLOW
OUTFLOW
DETENTION DAM ON AREA 1 TRIB.
(STRUCT. 1-B)
1. WATER SURFACE ELEVATION ASSUMED AS 312
2. SDF INFLOW
3. PRESS. CONDUIT 2-6'x6'
4. SPILLWAY CREST 325.0
PLATE 3

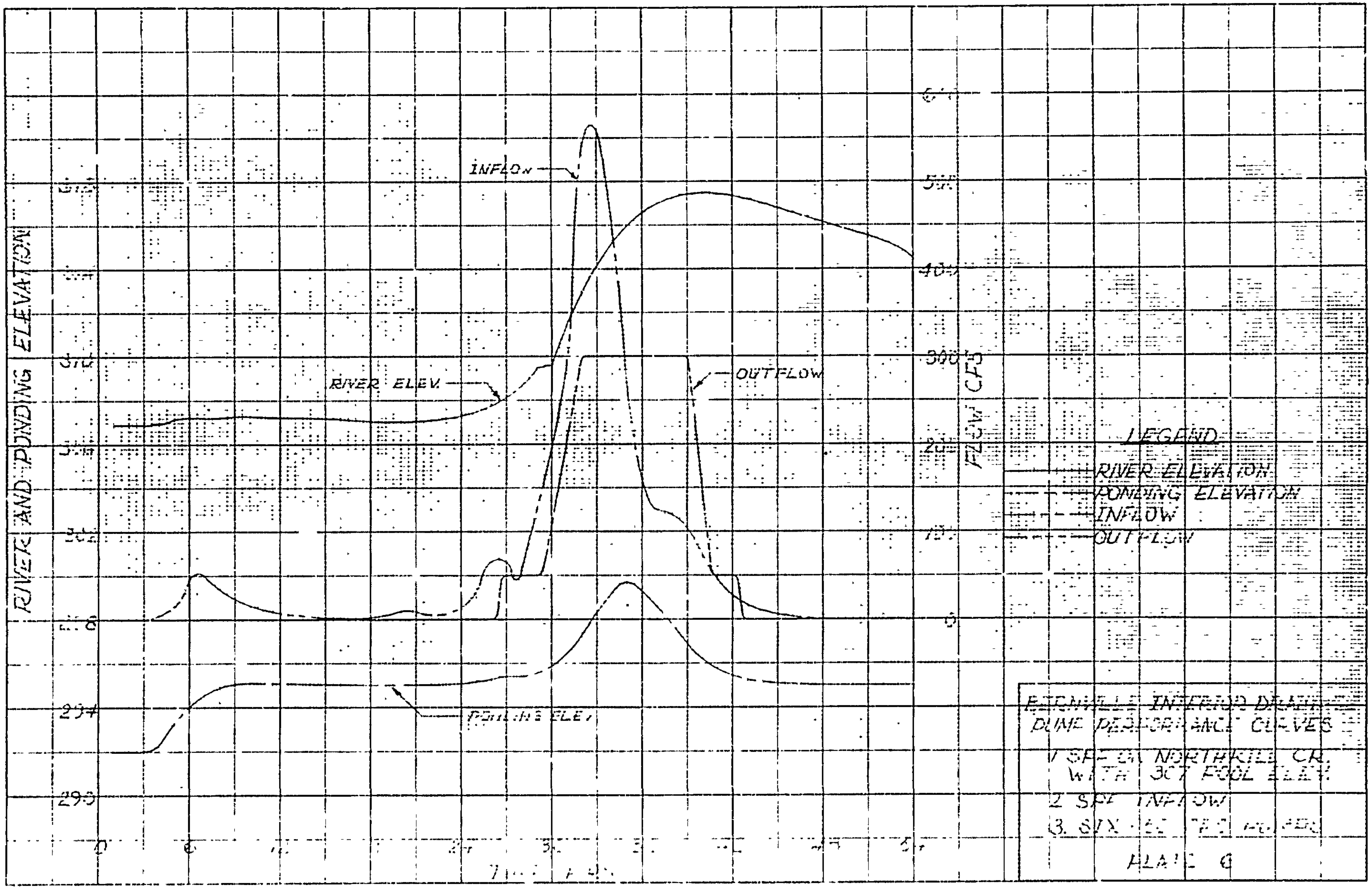


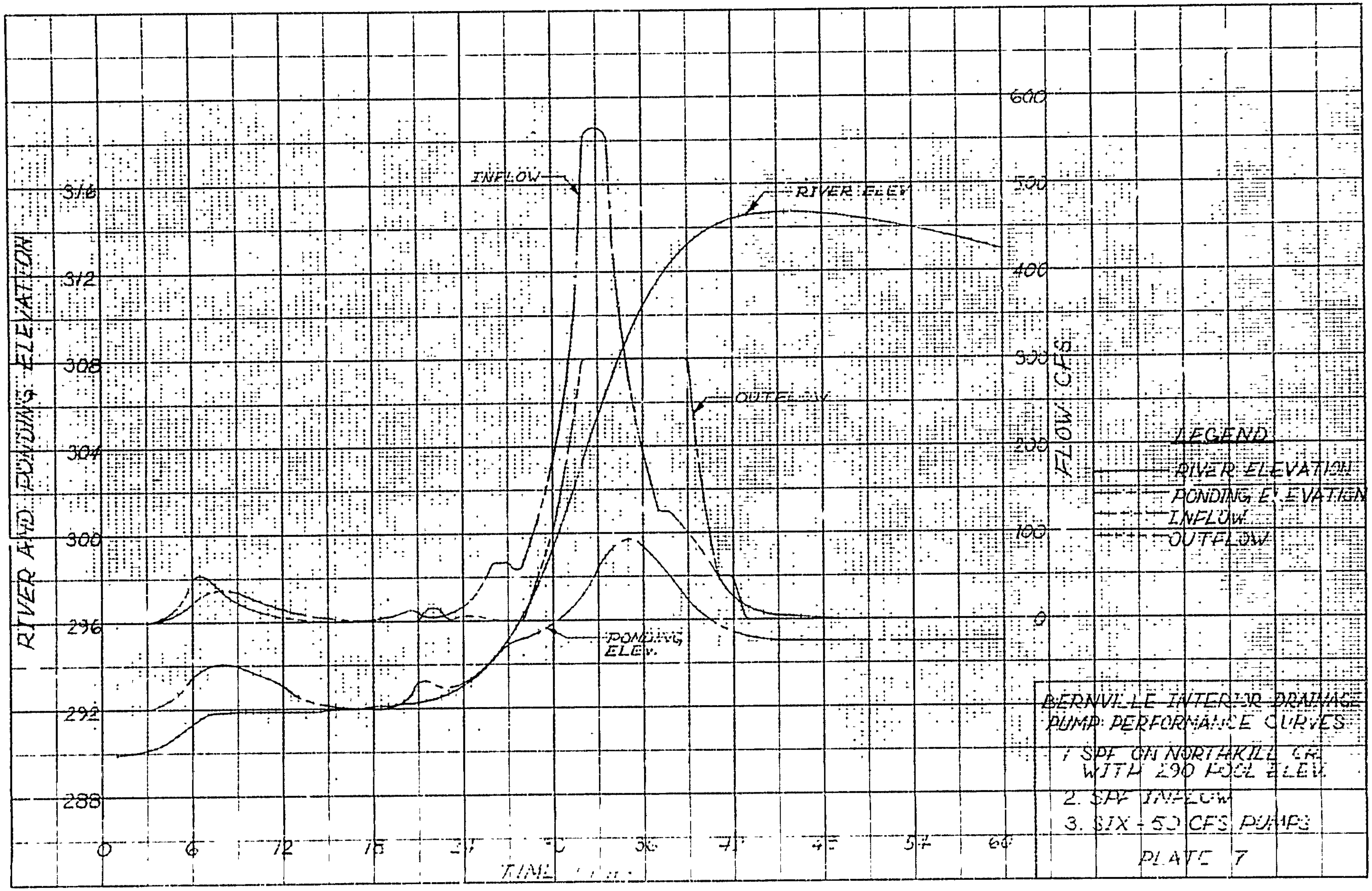
DETENTION DAM ON AREA 2 TRIB.
(STRUCT. 2A-1)

1. SPF ON NORTHKILL CR.
2. SPF INFLOW
3. PRESS. CONDUIT 2-6'x7'
4. SPILLWAY CREST 320.0

PLATE 4


RIVER AND PONDING ELEVATION
322
320
318
316
314
312
310
308
306
FLOW CFS
1800
1600
1400
1200
1000
800
400
PONDING ELEV.
INFLOW
OUTFLOW
0
6
12
24
48
54
TIME IN HR.
LEGEND
PONDING ELEVATION
INFLOW
OUTFLOW
DETENTION DAM ON AREA 2 TRIB.
(STRUCT. 2A-1)
1. NORTHKILL ASSUMED AS 317
2. SDF INFLOW
3. PRESS. CONDUIT 2-6'x7'
4. SPILLWAY CREST 320.0
PLATE 5


RIVER AND PONDING ELEVATION
FLOW CFS
INFLOW
OUTFLOW
RIVER ELEV.
PONDING ELEV.
LEGEND
RIVER ELEVATION
PONDING ELEVATION
INFLOW
OUTFLOW
310
306
302
298
294
290
0
6
30
0
100
200
300
400
500
PERFORMANCE CURVES
NORTHKILL CR.
WITH 307 POOL ELEV.
2 SPF INFLOW
PLATE 6



BERNVILLE INTERIOR DRAINAGE
PUMP PERFORMANCE CURVES

1. SPF ON NORTHKILL CR. WITH 290 POOL ELEV.
2. SPF INFLOW
3. SIX - 50 CFS PUMPS

PLATE 7

50 cfs

SUMP DIMENSIONS VERSUS FLOW

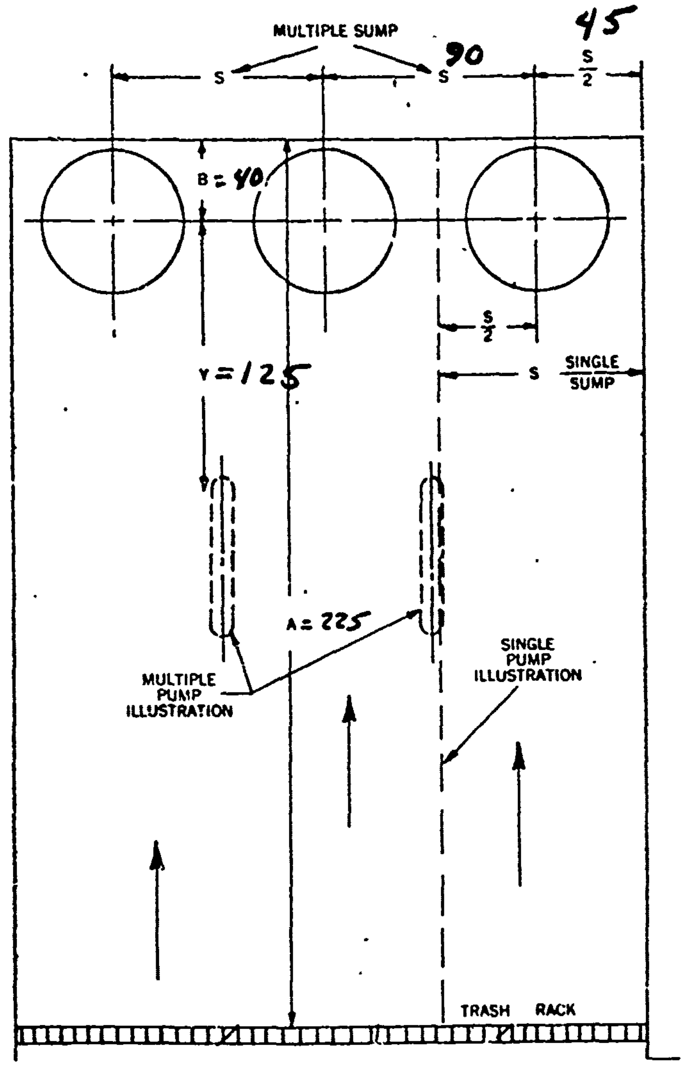


Fig. 65

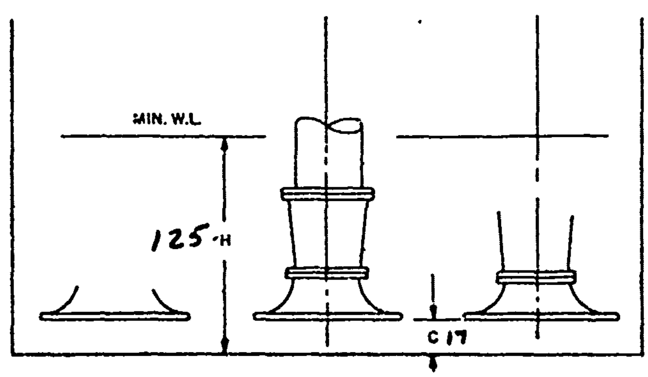


Plate 8

Fig. 66

100 cfs

SUMP DIMENSIONS VERSUS FLOW

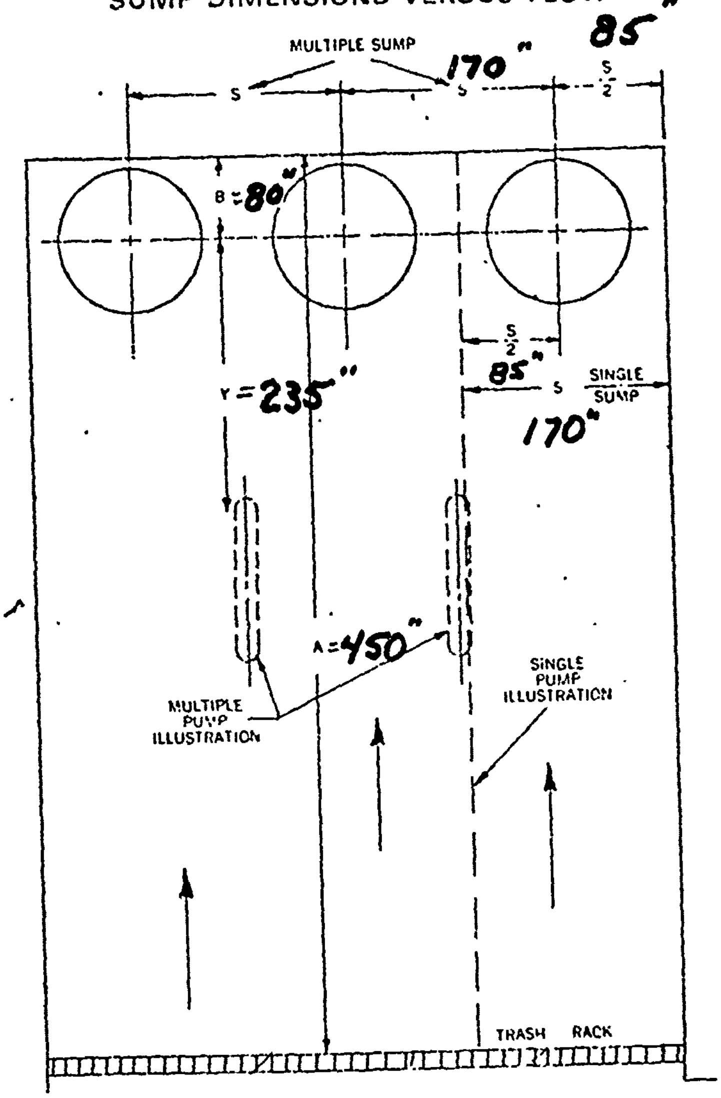


Fig. 65

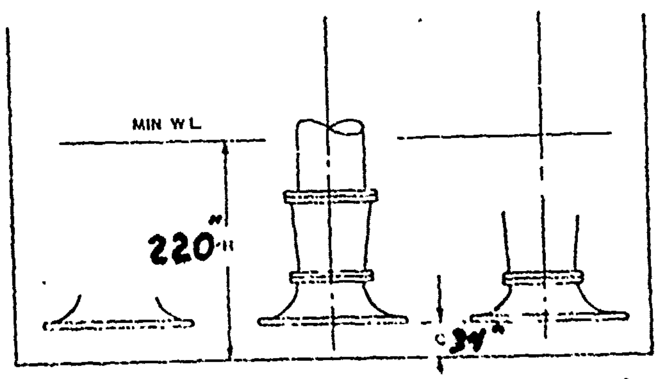
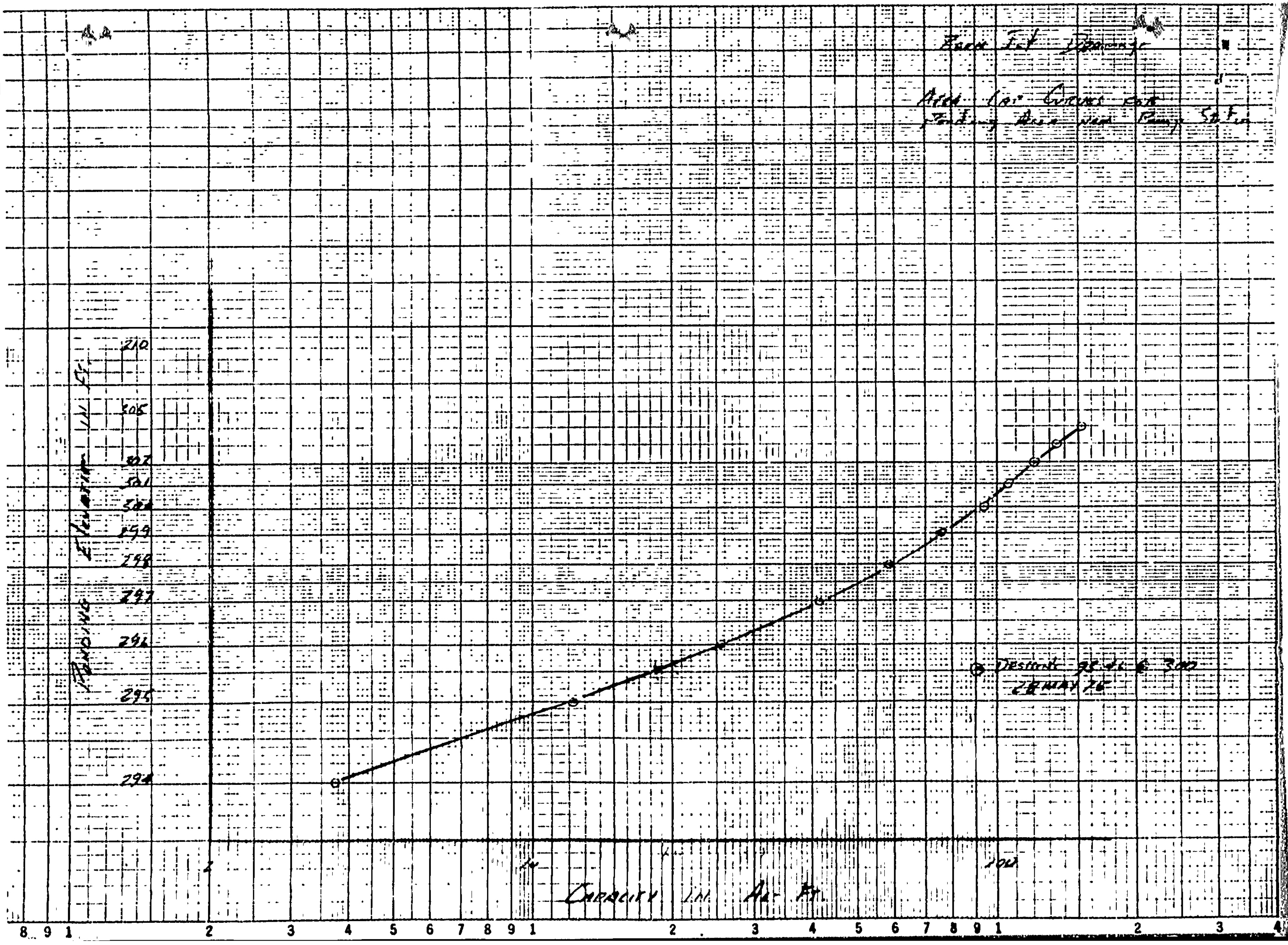


Plate 9



Area Cap. Curves for
Ponding Area near Pump Station
Ponding Elevation in Ft.
310
305
302
301
300
299
298
297
296
295
294
Capacity in Ac. Ft.
2
10
100
Design 98 Ac. @ 300

INCL. 15

Bern Int Drainage
AREA-CAP CURVE
28 MAY 75

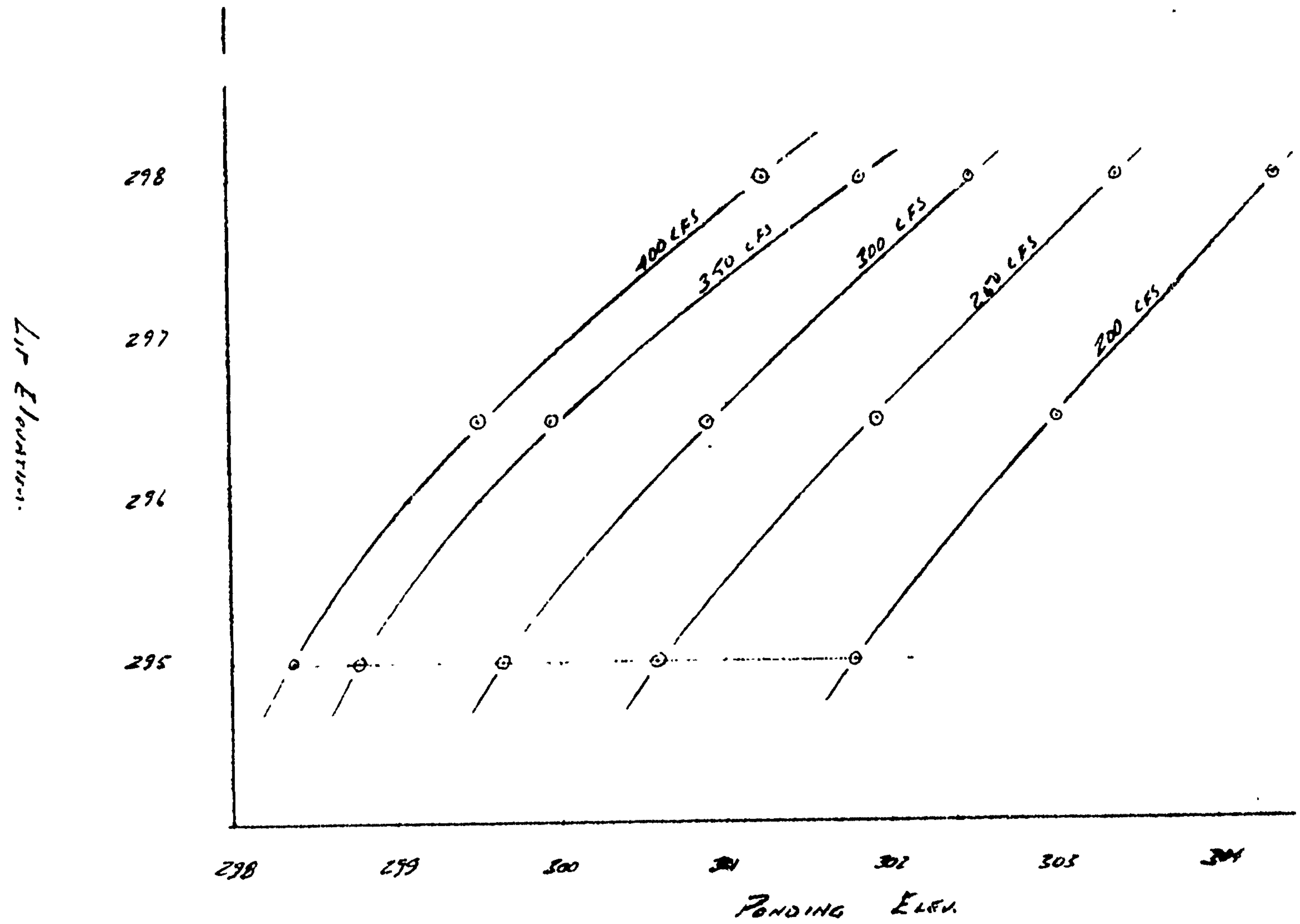
Elev.	(93.5@300) Design'B Curve
292	0
293 / 293.01	.65
294	3.15
295	12.25
296	25.86
297	41.65
298	58.69
299	75.93
300	93.46 *
301	106.8
302	121.3
303	136.6
304	152.7
305	171.7
306	194.0
307	224.6
308	255
309	293
310	345
312	446
315	621
320	1006

* CAPACITY FROM Elev 292 - 300 established by design Br.
CAPACITY FROM Elev 300+ established OR ESTIMATED
by Hydraulics Branch

Bern. Int Drainage

Pumping Requirements
in Conjunction with Area-Cap
Curve 93-46 @ 300'

Assumptions 1) Int. SPF from Area 3 only
2) 307-SPF on North Kill Ck



INCL. 16

Zern Jnt Drainage.

Pump Requirements in Conjunction
with Area - Cap Curve 93 76 @ 500'

Pump Curves

Pump Size	(Total)	Elevation Pump is Placed on Line		
		LP @ 296.0	LP @ 296.5	LP @ 298.0
50		295.4	296.7	298.2
50	(100)	295.7	297.0	298.4
50		296.0	297.2	298.7
50	(200)	296.2	297.4	298.9
50		296.5	297.7	299.2
50	(300)	296.7	298.0	299.4
50		296.9	298.2	299.7
50	(400)	297.1	298.4	299.9

BERNVILLE PROTECTIVE WORKS
300 C.F.S. Pump Plant

Electrical System.

Power Supply. The reduction in the capacity of the pumping plant, and consequently, the size of the pump motors, will enable us to use the existing 13.2 Kv feeder from the Bernville Substation (located approximately 2 mi west of the Boro) instead of constructing a 69 Kv tap line as discussed in the DM. Such a change will save approximately $100,000. This cost savings is, however, achieved at the expense of some loss of reliability since the 13.2 Kv line would be subject to possible vehicular damage and flooding. The flooding problem can be essentially eliminated by locating the poles above the flooding elevations and including a long span in the relocation of the 13.2 Kv line at the point where it crosses the Northkill Creek. A span of approximately 500 ft would allow this line to cross all low lying ground below elevation 320, without having any structures in this flood-prone zone. Any costs for improving the reliability of the 13.2 Kv power line will be subtracted from the anticipated cost savings.

Motors. Motors will be 200-250 hp (depending on final design), 2300-volt, 3-phase, 60-hertz, self-excited, synchronous type. The rating and quantity of motor starters will be revised to suit the motors.

Transformers.

Main Power Transformer. Capacity will be reduced to approximately 1500 KVA with primary voltage to suit selected source of power.

Station Service Transformer. Capacity will be reduced to correspond to the reduction in the station service load.

BY [illegible] DATE 6/10/75 SUBJECT MECHANICAL SHEET NO. 1 OF 7
CHKD. BY ______ DATE ______ Bernville Local Protection JOB NO. ______
Pump Station

300 CFS Pump Station

Basic Assumptions

1. The 300 cfs pumping capacity will be available at ponding elevation 300, station design point.
2. Single service power, 13.2 kv, will be provided.
3. Pump floor elevation at 308.
4. Pump size will be 50 cfs at design elevation
5. Pump station will be located inside levee
6. Gravity outfall will be a separate structure.
7. Pumps will have overlevee discharge lines.
8. Siphoning will be eliminated by vacuum breaker on top of levee.
9. All but one pump will shut off by elevation 295. One pump will pump ponding area to approximately 293.

Incl 8

BY ______________ DATE __________ SUBJECT **MECHANICAL** SHEET NO. 2 OF 7

CHKD. BY ________ DATE __________ Bernville Local Protection JOB NO ______________

centrifugal pumps applications

50 cfs

SUMP DIMENSIONS VERSUS FLOW

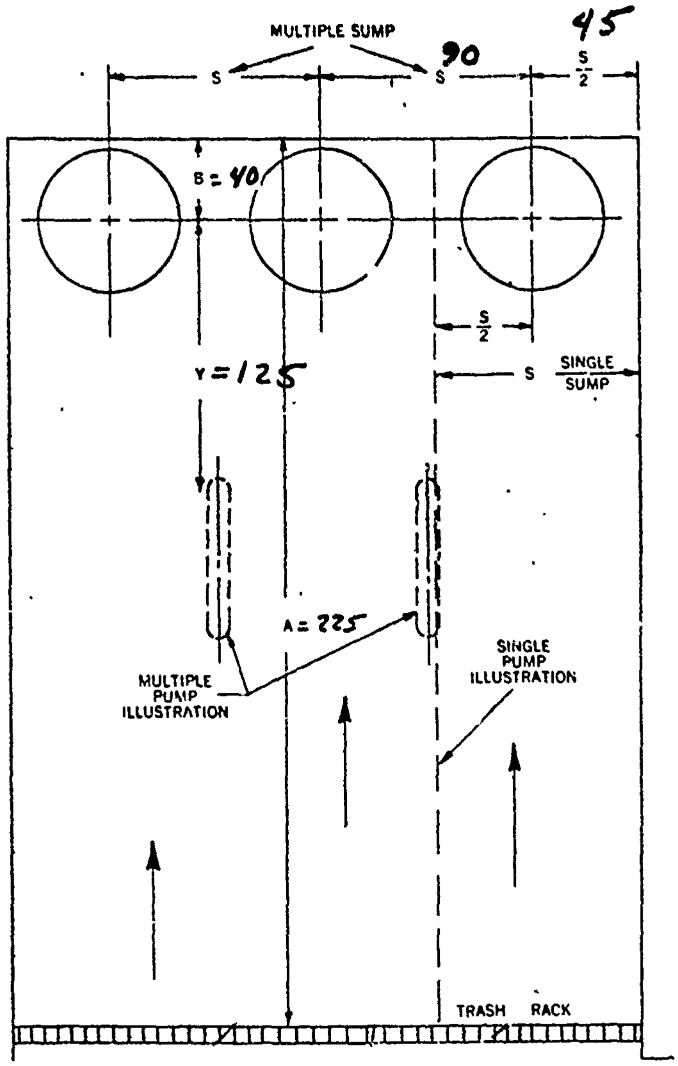


Fig. 65

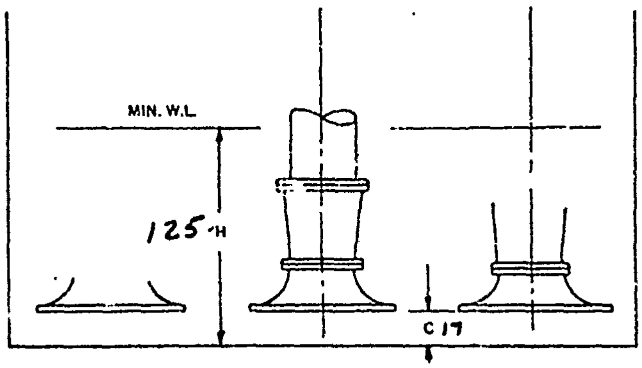


Fig. 66

BY [illegible] DATE 6/10/95 SUBJECT MECHANICAL Bernville Local Protection Pump Station SHEET NO. 3 OF 7
CHKD. BY ______ DATE ______ JOB NO. ______

Condition No. 1: Q_1 at maximum ponding elevation = 50 cfs or 22,400 gpm at 23 ft static head.

Condition No. 2: Q_2 at pump starting elevation = 46 cfs or 20,600 gpm at 28 ft static head.

1.) D_d = diameter of discharge line.

$$D_d = (4 \times Q_1 / 12\pi)^{1/2} \qquad \text{EM 1110-2-3105}$$
$$= (4 \times 50 / 12\pi)^{1/2}$$
$$= 2.3 \text{ ft or } 27.6$$

Use 30" O.D. pipe with 29.25" I.D.

2) Head Losses:

	Q_1 max	Q_1 Min	Q_2 Max	Q_2 min	Q_3 max	Q_3 min
1. Static head to top of pipe	23.0	23.0	28.0	280	30.0	30.0
2 Discharge line friction	4.35	1.74	3.7	1.48	3.30	1.32
3 Elbow friction	2.96	1.48	2.4	1.2	2.17	1.08
4. Exit loss	1.85	185	1.46	1.46	1.36	1.36
5. Flap valve loss	.01	—	.01	—	.01	—
	32.17	28.07	35.57	32.14	36.84	33.76

a) Min - pressure flow to top of levee, open channel flow down far side of levee
b) Max - pressure flow across levee, no siphoning.
c) Q_3 - at pump shutoff, min pumpdown flow

Condition No 3: Q_3 at minimum pumping elevation = 43 cfs or 19,300 gpm at 30 ft static head.

Discharge line friction 30" pipe with 29.25" I.D.
Velocity correction — 1.0585
Velocity head correction — 1.1208
Head loss /100 ft correction — 1.1492

Pipe I.D.	Q_1	Q_2	Q_3
30"			
$V =$	9.70 ft/sec	9.26 ft/sec	8.79 ft/sec
$H_v =$	1.65 ft	1.38 ft	1.21 ft
$H_f =$	1.51 ft/100 ft	1.29 ft/100 ft	1.15 ft/100 ft
29.25"			
$V =$	10.26 ft/sec	9.8 ft/sec	9.30 ft/sec
$H_v =$	1.85 ft	1.46 ft	1.36 ft
$H_f =$	1.74 ft/100 ft	1.48 ft/100 ft	1.32 ft/100 ft

100 ft of pipe $H_f =$	1.74 ft	1.48 ft	1.32 ft
250 ft of pipe $H_f =$	4.35 ft	3.70 ft	3.30 ft

BY ____ DATE ____ SUBJECT MECHANICAL SHEET NO. 5 OF 7
CHKD. BY ____ DATE ____ Bienville Local Protection JOB NO. ____

Elbow friction: Cameron Hydraulic Data Pg 50

$h_e = k \frac{V^2}{2g}$ $\qquad k = 1.25\left(\frac{45}{90}\right)^2(1.45^*) = .453$

* Average value for a mitre welded elbow.

$h_e = .453 \frac{(V^2)}{2g}$

@ Q_1 : h_e = .74 ft ; @ Q_2 : h_e = .60 ft ; @ Q_3 : h_e = .54 ft

Flap gate losses: Hydraulic Design Criteria,

$h_L = k \frac{V^2}{2g}$ $\qquad H_v = V^2/2g$

Q_1 — H_v = 1.85 ; D/H_v = 1.31 ; k_Q = .01 ; h_L = .018

Q_2 — H_v = 1.46 ; D/H_v = 1.66 ; k_{Q_2} = .01 ; h_L = .015

Q_3 — H_v = 1.36 ; D/H_v = 1.79 ; k_{Q_3} = .01 ; h_L = .014

BY .... DATE .... SUBJECT MECHANICAL SHEET NO. 6 OF 7
CHKD. BY .... DATE .... Bernville Local Protection JOB NO. ....

Flow through Gate Opening:

7 ft opening; approaches rectangular weir flow
Theoretical Weir Mech Eng Hd Bk Pg 3-71

$Q = \frac{2}{3} C l h \sqrt{2gh}$ $C = .62$ $l = 7$ ft $h = ?$

$Q^2 = \frac{4C^2 l^2 h^2 (2gh)}{9}$

$h = \left(9Q^2 / (8C^2 l^2 g)\right)^{1/3}$

@ Q = 50 cfs; h = 1.67 ft.
Critical h to pass 50 cfs through a gate opening. Use h = 2 ft.

Assuming equal flow through all six trashracks
@ Q = 43 cfs
l = 8 ft } h = .42 ft
Minimum h to pump 43 cfs just before pump shut down.
Water velocity across 293.0 lip = 7.17 fps
Minimum pumping elevation for storm pumps — Elevation 293.42.

Notch Weir:
$Q = 3.33 (l - .2h) h^{3/2}$
@ $l = 7$, $h = 2$; $Q = 62.16$ cfs ok

Trashrack Losses:

Hydraulic Design Criteria, Chart 010-7

Trashrack bars: 3/8" × 3" ∴ $L/t = 8$

Bar spacing 3" on centers

Use unit height to determine Area ratio

$$A_r = \frac{\text{Area of Bars}}{\text{Area of Section}} = \frac{3/8 \text{ in}^2}{3\,3/8 \text{ in}^2} = .111$$

$$\therefore K_t = .09$$

$$K_t = \Delta h / \tfrac{V^2}{2g} \quad ; \quad \Delta h = K_t V^2/2g$$

Use A as projected area on vertical plane

@ h = 1.67 ft ; 50 cfs through a single bay

A = 13.36 ft² ; V = 3.75 ft/sec

Δh = .02 ft

∴ Total h must be 1.69 ft.

Using 2 ft ok

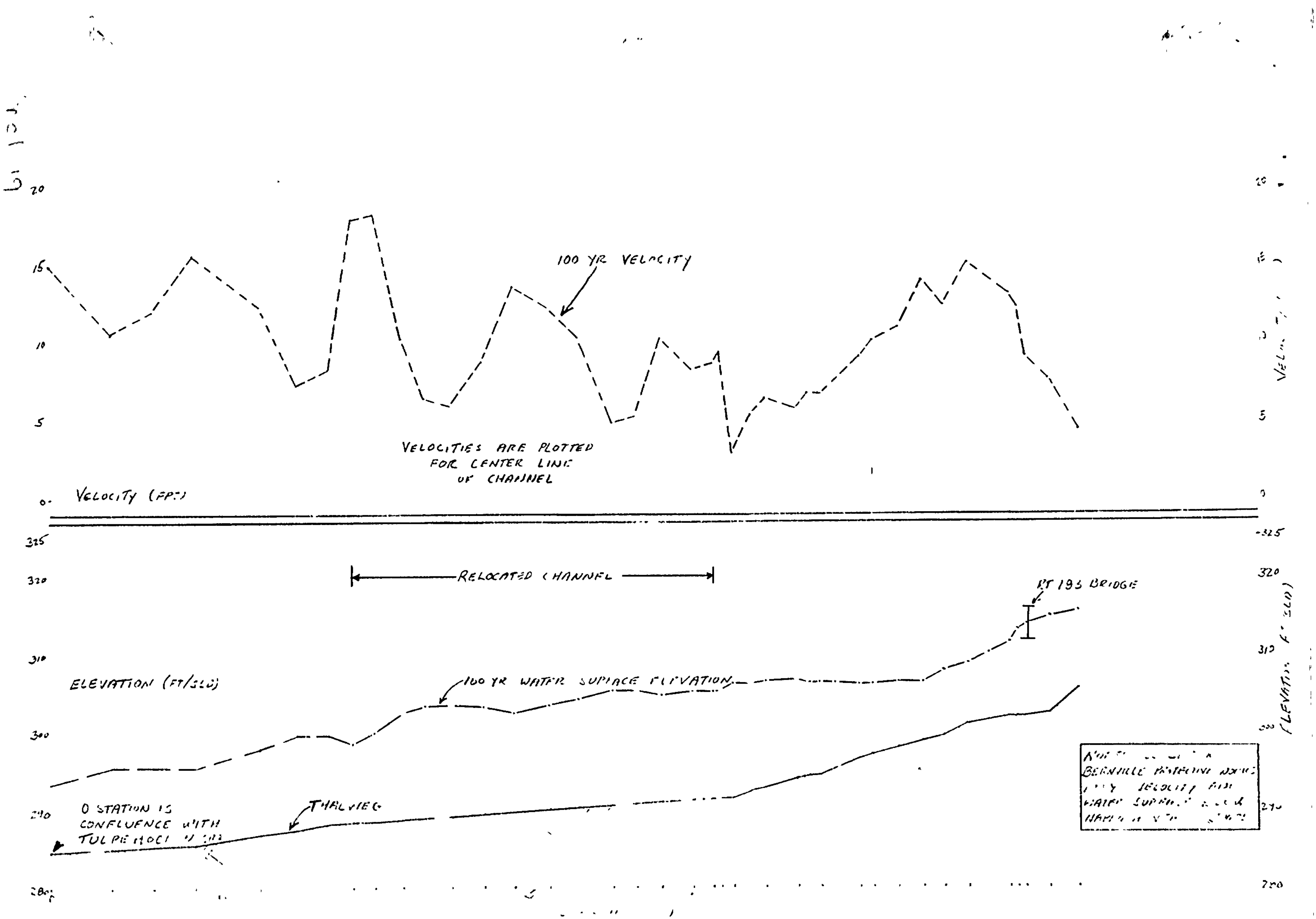
@ h = .42 ft ; Minimum h to pass 43 cfs through six trashrack to supply one pump. A = 3.36 ft² V = 2.13 ft/sec

Δh = .006 ft.

@ h = 7 ft. ; 50 cfs at max pond elevation 300

A = 56 ft²; V = .89 ft/sec.

Δh = .001 ft.



100 YR VELOCITY
VELOCITIES ARE PLOTTED FOR CENTER LINE OF CHANNEL
VELOCITY (FPS)
RELOCATED CHANNEL
RT 183 BRIDGE
ELEVATION (FT/SLD)
100 YR WATER SURFACE ELEVATION
THALWEG
0 STATION IS CONFLUENCE WITH TULPEHOCKEN
20
15
10
5
0
325
320
310
300
290
280

NADEN-MG (16 Jan 75) 3rd Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13 - Bernville Protective Works

DA, North Atlantic Division, Corps of Engineers, 90 Church Street, New York, NY 10007 22 May 1975

TO: District Engineer, Philadelphia ATTN: NAPEN-D

1. To note that the subject Design Memorandum is satisfactory as a basis for further planning subject to OCE and NAD comments and that approval of the interior drainage feature is withheld pending further studies and review of the supplemental information resulting therefrom.

2. Information on a tentative schedule for the review conference suggested by OCE should be furnished this office as soon as possible.

FOR THE DIVISION ENGINEER:

M. Schechet
M. SCHECHET
Chief, Engineering Division

DAEN-CWE-B (NAPEN-D, 16 Jan 75) 2nd Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13 - Bernville Protective Works

DA, Office of the Chief of Engineers, Washington, D.C. 20314 16 May 1975

TO: Division Engineer, North Atlantic, ATTN: NADEN-MG

1. Approved, subject to the comments of the Division Engineer in the 1st Indorsement and inclosures thereto and to the comments in the following paragraphs. The concept embodied in Alternate E, interior drainage, is satisfactory; however, since the pumping station will be materially affected by Alternate E, approval of the interior drainage feature is withheld pending further studies and review and approval of supplemental information resulting therefrom. In addition, in view of the proposed schedule for this project and since the two detention dams remain under design, a review conference is suggested at such time as sufficient field data is available and the design is developed.

2. Paragraph 4-05b and Plates 8, 10 and 13. In the levee reach south of Station 48±, the more highly fractured and deeply weathered foundation rock at the core trench contact, in combination with the proposed landside drainage ditch cut into or through the pervious foundation gravels, could lead to damaging underseepage with successive pool fluctuation. Care should be exercised to contractually allow for its deepening to a sound condition, and provisions for sidewall filters and rock surface treatment should be included.

3. Paragraph 4-07a and Plates 28 through 31. A discussion should be furnished on the rehabilitation of borrow areas Alpha and Bravo. The planting plans shown on these plates do not include the borrow areas. In addition to the criteria stated in paragraph 4-07a, the location of the borrow areas should be based on an evaluation of the effects the borrow areas would have on the environment.

4. Paragraph 7-03d. All pump discharge lines should be constructed using steel pipe.

5. Paragraph 7-04c. In view of the cost involved in obtaining electric power, it appears that consideration should be given to using deisel engine for powering the storm water pumps.

6. Paragraph 7-04d. Motors of the proposed size are not suited to a cycling type service where frequent starts are required. If such operation is envisioned a valved bypass should be installed to bypass a part of the pump discharge back to the sump; frequent starts can thus be avoided.

DAEN-CWE-B (NAPEN-D, 16 Jan 75) 2nd Ind 16 May 1975
SUBJECT: Blue Marsh Lake Design Memorandum No. 13 - Bernville
Protective Works

7. Paragraph 7-04g(1). Sufficient lighting to preclude the use of portable lights for routine maintenance should be provided in the sump.

8. Plate 24. The pump discharge lines should go over top of the impervious core rather than through it.

9. Appendix C. Electrical calculations including fault current calculations used for determining the rating and interrupting capacity of the circuit breakers and fuses should be incorporated in this appendix.

10. In paragraph 6-02 of the General Design Memorandum for the subject project, there is a statement that the Bernville Protective Works were not presented in the authorizing document except for a need of minor land acquisition; upon further analysis of the standard project flood, it was then determined that the provision of protective works would be more economical and practical than the acquisition of pertinent properties. The subject design memorandum should contain a statement as to whether this is still the case.

FOR THE CHIEF OF ENGINEERS:

wd all incl

C. E. Slayton
for HOMER B. WILLIS
Chief, Engineering Division
Directorate of Civil Works

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314

IN REPLY REFER TO

DAEN-CWE-B

16 May 1975

SUBJECT: Blue Marsh Lake Design Memorandum No. 13 - Bernville Protective Works

District Engineer, Philadelphia

Extra copies of the subject material, having served their purpose, are returned herewith.

FOR THE CHIEF OF ENGINEERS:

1 Incl (9 cys)
as

C. E. Slayton
CHARLES E. SLAYTON
Chief, Project Engineering Branch
Engineering Division, Civil Works

ENG FL 33, Sep 71

NORTH ATLANTIC DIVISION, CORPS OF ENGINEERS

NEW YORK, N. Y. 10007

NADEN-MG   23 January 1975

SUBJECT: Blue Marsh Lake, D. M. No. 13, Bernville Protective Works

HQDA (DAEN-CWE-B)
WASH DC

1. Six copies of the subject memorandum, which includes a major pumping station are forwarded for your examination prior to completion of NAD review.

2. Concurrent review is requested in order to meet our schedule for construction award in August 1975 of the protective works at Bernville, Pa.

FOR THE DIVISION ENGINEER:

1 Incl
as

s/M. SCHECHET
Chief, Engineering Division

NADEN-MG (16 Jan 75) 1st Ind
SUBJECT: Blue Marsh Lake Design Memorandum No. 13 - Bernville Protective Works

DA, North Atlantic Division, Corps of Engineers, 90 Church Street
New York, N.Y. 10007 11 April 1975

TO: HQDA (DAEN-CWE-B), WASH DC 20314

1. Reference is made to NADEN-MG letter dated 23 January 1975, subject as above, which furnished 6 copies of subject memorandum for concurrent review by your office.

2. During review of the interior drainage provisions presented in the subject DM, it was determined that, due to the rapid hydrologic response of the small drainage area above Bernville on Northkill Creek, it was likely that gravity outflow of runoff from major rainfall events would be blocked. Routing studies further disclosed that during the levee design flood, with the proposed 800 cfs pumping plant in operation, interior drainage could pond to within 4-6 feet of the elevation of the levee design water surface, affecting essentially the entire protected area and causing excessive flood damage.

3. Following the above analyses, studies were made of alternate plans that would provide a higher degree of protection against interior flooding. As indicated by Alternate E in inclosure 2, the District has found that by diverting two streams which drain about 80 percent of the interior drainage area, and increasing the ponding capacity by excavation, a high degree of protection can be provided and the size of the pumping plant substantially reduced. This scheme would include two SPF-sized pressure conduits with intake dams containing about 30-45 acre feet of storage at spillway crest, and a pumping plant with capacity of about 290 cfs. The total Bernville project cost would be essentially the same as initially proposed in DM No. 13.

4. In view of the critical time schedule for this project, it is recommended that the concept embodied in Alternate E be approved as a basis for preparation of plans and specifications subject to the NAD review comments in Inclosure 3. In addition, it is recommended that, except for interior drainage provisions, DM No. 13 be approved subject to the NAD review comments in inclosure 4.

5. In the event there are concerns regarding the proposed project design, a meeting with NAP and NAD personnel will be scheduled at your convenience.

FOR THE DIVISION ENGINEER:

4 Incl
1. 12 cys w/d
Added 3 Incl (13 cys ea)
2. NAP ltr 4 Apr 75 w/incl rpf
3. NAD Review Comments 11 April 75
4. NAD Review Comments 4 March 75

M. SCHECHET
Chief, Engineering Division

CC: DE, Philadelphia

11 April 1975

NAP REPORT ON ALTERNATE STUDIES - MAR. 1975
BERNVILLE PROTECTIVE WORKS

NAD REVIEW COMMENTS

a. Paragraph 3, page 2. It is understood that the cost of relocating the electric substation might be as low as $150,000. This should be included in recommended Alternate E in order to preclude the loss of power to the area in the event operating difficulties are encountered at the pump station during a storm.

b. Paragraph 4, page 4. The diversion facilities for tributaries 1 and 2 should be checked for floods up to PMF magnitude to insure that increased hazards will not occur below the dams due to higher velocities and/or stages.

c. Paragraph 5, page 4. It is not clear whether cost savings could be realized through elimination of the wall at the sewage treatment plan for the recommended scheme. This should be reviewed.

d. Paragraph 5b, page 5. For clarification, it is understood that for Alternates B-E, the size of the intake dam is fixed while the size of the pressure conduit (s) varies to correspond with the indicated event.

e. Paragraph 5c, page 6. There appears to be little economic justification for providing a pump station on the order of 300 cfs. In view of the remote possibility of the extreme SPF event, the relocation of the electric substation recommended in paragraph a above, the low residual damage on an annual basis, and the fact that easements would not normally be required to an extreme flood level, consideration should be given to allowing the SPF event to exceed elevation 300 somewhat, thereby reducing required pump capacity.

f. Paragraph 5e, page 7. It is understood that the damages in the third column of the table assume that the electric substations has been relocated. However, the nature of the indicated damage, including the handling of the sewage treatment plant, is not clear. This should be carefully reviewed in connection with the evaluation of paragraph e, above.

g. Paragraph 6a, page 7. Under the recommended scheme, the dams and conduits for tributaries 1 and 2 are sized for the SPF component of the reservoir SPF. Consideration should be given to using the SPF for each individual tributary, if significantly larger.

h. Paragraph 6d, page 9. Additional economic evaluation studies should be made to determine the feasibility of further enlarging the ponding area and reducing pumping capacity, thereby tending to minimize O & M costs.

i. Paragraph 7a, page 9. While this office does not interpret the reference as requiring design for an interior storm equivalent to that used for a levee at a reservoir project, consideration of the disposition of the interior runoff coincident with the levee design flood is pertinent.

INCL 3

4 March 1975

NAD REVIEW COMMENTS
DM 13, BERNVILLE PROTECTIVE WORKS

a. Paragraph 3-03b. The planting guidelines in EM 1110-2-301 are applicable to this project regardless of the limitations and restraints indicated. The roots of plantings may not penetrate the levee structure and the density of plantings should not prevent the inspection of toe areas for boils during flood periods. A review and revision of the location of plantings between Station 12+00 and 17+00, 29+50 and 33+00, 40+70 and 41+70, and 47+30 and 56+20 should be accomplished. The followng plant species are shown incorrectly in Table 1:

(1) "Pinus sylrestris" should be Pinus sylvestris.

(2) "Hemorocallus fulva - common Daylily" should be Hemerocallis fulva - Tawny Daylilly.

(3) "Shus sp." should be Rhus sp.

(4) "Rubus strigosus - Wild Raspberry" should be Rubus idaeus strigosus-American Red Raspberry.

b. Paragraph 4-05c. If final design requires excavation of soft clays beneath the embankment, the areal extent of these deposits should be delineated before preparation of final plans and specifications so that consideration may be given to this item in the cost estimate.

c. Paragraph 4-06a. Line 14 - change "strength" to read "stretch".

d. Paragraph 4-07e. The number of passes should be indicated.

e. Paragraph 7-01. The foundation conditions for the pumping station and drainage structures should be covered.

f. Paragraph 7-02b. Seismic loads should be considered in accordance with ETL 1110-2-109 (21 October 1970).

g. Paragraph 7-04. In determining pumping plant costs consideration must be given to demand charges. When these charges are considered an analysis should be made as to the most economical plant size as well as whether direct engine drives should be considered. The cost of creating a greater ponding area may be economically justified when all plant costs are considered.

h. Plates 3 and 11. Consideration should be given to moving the flanking levee with its nearly 20-foot height and gated gravity outlet structure to a point about 800 feet upstream close to the divide where the height would be about 5 feet and a gravity outlet structure would not be required. The length of the top of the flanking levee would be about the same for either location.

INCL 4

i. Plates 5 and 6. In the highway section which functions as a levee, the location of the impervious core centerline should be indicated. Horizontal transitions should be carefully developed to insure ease of placement and proper compaction. The details of the crossing of the core beneath the road structure should also be included.

j. Plate 8. The removal of the existing Robesonia Road Bridge and the six-foot high dam located downstream of the bridge is not mentioned in the text nor shown as a cost item.

k. Plate 13. Typical Sections-Sta. 29+35 to 53+30 and Sta. 56+35 to 58+90. The reason for placing pervious fill at the toe of the protected side of the levee is not clear. A positive, reasonably good cut-off will be effected with the impervious core on rock and submergence of the levee will be infrequent so that there will be little underseepage or through-seepage. Also, the cost estimate (Section 12) does not contain a pervious fill item. The deletion of this item for sake of economy is recommended.

l. Plate 21. For final design it is recommended that (a) the sluice gate manhole be moved off the crown of the levee in order to provide sufficient clearance for the gate stem from the gravel roadway and (b) the seepage diaphragm be deleted.

m. Plate 22.. The seepage diaphragm should be deleted.

n. Plate 32. The upper left graph shows interior drainage inflow, outflow, and ponding elevation vs. time in hours. At 3 1/2 hours the outflow is 650 cfs with the pond level below elevation 293 feet. At 7 hours the outflow is also shown as 650 cfs with the pond at elevation 293 feet. Since the control sill to the pumping station is at elevation 293.0 feet (plate 8), pumping outflow would be zero with the pond at elevation 293 feet. The gravity outlet with the pond at this level would pass 20 cfs (see graph in lower left corner of Plate 32). Zero cfs pumping plus 20 cfs gravity flow does not add up to the indicated 650 cfs outflow. This apparent inconsistancy should be explained.

o. Plate 35. A velocity profile should be included. In addition, the levee stationing should be shown, or preferable, creek stations should be established and indicated on plan views and profiles for ease of cross referencing.

p. Appendix A. Engineering Form 2086 should be used to summarize all test data.

q. Plates A-1, A -2, and A-3. The gradation curves of the lower foundation material from SAT-10 indicate that the material is a highly pervious zone.

With the exception of the coarse to fine gravel strata in SAT-3, the classifications in the other borings and test trench logs do not reflect, or convey to prospective contractors, this highly porous condition. It will be necessary to dewater this zone forthe proper construction of the cutoff. It is therefore recommended for the development of contract plans that classifications be checked and corrections be made where necessary. Also, additional field tests should be accomplished and presented to accurately portray this condition.

r. Plates A-2, A-6 and A-12. Boring SAB-21 on Plate A-2 indicates that the material is CH whereas Plates A-6 and A-12 show it to be OH. A clarification is required. Also, the stratification and logging information appear in error when compared to the test data. Undisturbed samples were apparently taken from 2 to 6 feet and blow counts are indicated on the logs.

s. Plate A-6. Index Design I, J, and L appear to be GW or GW-GC materials. It is requested that this as well as the log classifications be reviewed.

t. Plates A-7, A-9, and A-10. EM 1110-2-1902 requires that R tests be fully saturated by means of back pressure. Test data on the indicated plates show 62 to 80 percent saturation. The reasons for using these lower saturations should be indicated.

u. Appendix C, Page 19. The computed corner bearing pressure of roughly 5 tons per square foot is considered high, even though the soil is confined under 25 feet of fill and will be well compacted. It is recommended that structural plate steel pipe arches with corner radius equal to 31 inches be used in lieu of the 18 inches presently indicated This would reduce the corner bearing stress to roughly 3 tons per square foot.

ENGR DIV
CALVARESE/db/47
4 Apr 75

VINCI

4 April 75

NAPEN-D

DILLEY

SUBJECT: Blue Marsh Lake Design Memorandum No. 13, Bernville Protective Works

PHILLIPS

Division Engineer, North Atlantic
ATTN: NADEN-T

1. As requested during our meetings of 7 and 25 March 1975, we have reviewed the proposed interior drainage at Bernville, Pennsylvania. Our study revealed that due to the small drainage area involved, the various events for interior drainage coincedent with high stages in the reservoir as presented in the DM for Bernville are of high frequency and not in general agreement with other project design criteria. We feel protection provided behind the leveed areas against interior flooding, should be in the same range as that afforded by the levees against reservoir flooding of the Boro.

2. The District has therefore made a study of alternate methods to provide increased protection and has presented the results along with a recommendation in the inclosed report.

3. It is requested that prompt review of this study be accomplished by your office. Upon receipt of your comments on this report, the District will prepare formal revisions to DM #13, Bernville Protective Works. Pending approval of these changes we are, however, proceeding with those portions of the plans and specifications not directly affected by these changes.

4. It should be noted that an exploration and testing program has been developed for the design of the two detention dams. Data from these explorations and the design for the dams, however, are not expected to be available for the revisions noted above. This information will be submitted to NAD at a later date for review. In order to expedite approval of this data, it is further requested that authority be obtained for review and approval at Division level.

FOR THE DISTRICT ENGINEER:

1 Incl
As stated

WORTH D. PHILLIPS
Chief, Engineering Division

M/R Self-explanatory
CALVARESE

BLUE MARSH LAKE
DESIGN MEMORANDUM NO. 13
BERNVILLE PROTECTIVE WORKS

ALTERNATE STUDIES
MARCH 1975

1. <u>General</u>

The potential flooding of Bernville Boro has been increased by construction of the Blue Marsh Lake Project and therefore is not a standard local flood protection project, with the locals sharing the cost. In this case, the Corps of Engineers would purchase all real estate, pay for all construction, relocations, and operate and maintain the entire protection system.

Because the area to be protected by levees was not subject to the same level of flooding prior to the construction of the reservoir project, substantially higher degree of protection against interior flooding should be provided.

2. <u>Present Flooding Conditions</u>

The flooding potential at Bernville without local protective works or the Blue Marsh Dam, was investigated for the existing conditions. The 10, 50, 100 yr., and SPF event were routed through the area. The results indicate probable flood levels at Bernville as follows:

<u>Pre-Project Flooding</u>

Event	Elev
10 - year	300.1
50 - year	301.6
100 - year	302.3
SPF	306.2

3. Ponding Area

The existing topography is such that a natural low lying area encompassed by contour Elevation 300 immediately behind the protective levees is relatively uninhabited and presently acts as an overbank flood plain. This makes an ideal ponding area and was therefore selected and used in DM #13. Immediately above elevation 300, commercial establishments and private residences have been constructed along with a 13.2 KVA substation at elev 301.5 which feeds electric energy to the town. Because of the proximity of improvements above elevation 300, it was fixed as the upper allowable elevation of flooding from project induced flooding. Intermittent flooding above this elevation would require purchase of flowage easements, and relocation of the 13.2 KVA substation. Flooding above elevation 303 would inundate the sewage treatment facility adjacent to the pumping station.

It should be further noted that in all meetings with locals, Elevation 300 was given as highest flooding elevation, and Real Estate acquisition has been based on same.

4. Alternate Plans Studied

Four Alternate plans were investigated and priced to determine the most economical method of handling various interior design storms coincident with high reservoir stages. Several plans were investigated under each alternate, such as; tie back levees, different locations for detention dams, and increasing the volume of the ponding area. Several site plans were checked for each alternate, but only the most acceptable and economical plan is briefly presented below.

ALTERNATE A: Provide interior drainage protection as shown in DM #13, Bernville Protective Works, utilizing a larger pumping station to provide additional protection. This plan would also require varying the size of the two large culverts under LR 310.

ALTERNATE B: Diversion of upper tributary (#1) by means of a dam and a concrete conduit. This plan would divert inflow directly to the Northkill Creek thus reducing pumping requirements, and the required size of the long culvert under LR 310. The dam would have a top elevation of 331.5 with a 50' wide spillway cut into existing rock with a crest elevation of 325. This plan requires additional real estate mostly in the form of flowage easement.

ALTERNATE C: Diversion of the middle tributary (#2) by means of a dam and a concrete conduit. The conduit would divert the natural inflow directly to the Northkill Creek, thus reducing the pumping requirements for interior drainage. The dam would consist of an earthfill section with a top elevation of 325, and a 100' wide gravity concrete spillway with a crest at elevation 320. This alternate would also reduce the size of the culvert under LR 310, and require additional real estate mostly in the form of flowage easement.

ALTERNATE D: This alternate would combine B and C above, i.e., divert both the upper (#1) and middle (#2) tributaries through culverts to the Northkill Creek thereby substantially reducing the size of pumping station required under any design storm. This is the recommended Plan.

ALTERNATE E: Same as "D" above plus excavation of ponding area. It is anticipated that some portion of the excavated material will be used in the construction of the levee. The excavation will be graded to drain to the gravity outlet and seeded.

5. Costs

a. The estimated cost of each alternate was prepared for 10 yr, 50 yr, 100 yr, and SPF events for 2 different ponding elevations. One being elevation 300 (no-damage) and the other being the elevation of potential flooding prior to the project for any one event. The latter ponding elevation varies from El 300 to El 306. The estimated costs for all alternates include real estate and relocations. This information is summarized below along with the required pumping in cfs for the pumping station.

b. It can be seen from the following summary that the cost of ponding to pre-project damage levels (Elev 300-306) is greater than a no-damage level (Elev 300) and is due to additional relocation and real estate cost.

PLANS	Ponding Elevation El 300		Ponding Elevation Varies 300-306		
	NO-DAMAGE		PRE-PROJECT FLOODING		
Alternate A	Pumping Required CFS	Total Project Cost	Pumping Required	Ponding Elev	Total Proje Cost
(DM #13) 10 year event	800	$7,800,000	790	300.1	$7,600,CO

50 year event	1000	8,900,000	900	301.6	8,900,000
100 year event	1100	9,100,000	1000	302.3	9,500,000
SPF event	2100	12,600,000	1600	306.2	12,200,000
ALTERNATE B (Divert #1)					
10 year event	350	7,000,000	340	300.1	6,800,000
50 year event	600	7,500,000	500	301.6	7,900,000
100 year event	600	7,600,000	500	302.3	8,400,000
SPF event	1100	9,600,000	700	306.2	9,400,000
ALTERNATE C (Divert #2)					
10 year event	400	7,500,000	390	300.1	7,400,000
50 year event	700	8,500,000	600	301.6	8,400,000
100 year event	710	8,600,000	600	302.3	8,900,000
SPF event	1340	10,700,000	900	306.2	10,600,000
ALTERNATE D (Divert #1 & #2)					
10 year event	45	6,300,000	40	300.1	6,100,000
50 year event	100	6,600,000	50	301.6	6,700,00
100 year event	110	6,900,000	40	302.3	7,100,00
SPF event	340	8,000,000	120	306.2	8,600,00
ALTERNATE E (Divert #1 & #2 plus excavation of Ponding Area)					
100 year event	60	7,300,000	15	302.3	7,300,00
SPF event	290	7,900,000	90	306.2	8,400,00

c. In addition to the alternates above, some further studies were made under Alternate E to determine the effect of a fixed size pumping station on the ponding elevation for various interior storms. The results are as follows:

Ponding Elevation

Pumping Station Capacity

Event	100 cfs	150 cfs	200 cfs	300 cfs
10	El 296.5	El 296.0	El 295.3	293.6
50	299.0	297.2	296.5	294.0
100	299.5	298.3	297.1	295.3
250	302.5	301.2	300.0	297.5
SPF	306.0	304.5	303.0	300.0

Those ponding elevations below the dark line would cause damage and require real Estate acquisition and/or relocations.

d. The estimated cost of Real Estate and Relocations for various elevations are as follows:

Elev	Increment Cost	Total Cost
300	0	0
301	$250,000	250,000
302	220,000	470,000
303	380,000	850,000
304	260,000	1,110,000
305	140,000	1,250,000
306	60,000	1,310,000

e. An example of the cost of damages versus increased pumping (without excavated ponding area) is shown below.

Ponding Elevation	R. E. Damages Increment	Total	Pumping CFS	Total Cost Pumping Station
300	0	0	340	1,800,000
301	100,000	100,000	300	1,700,000
302	90,000	190,000	260	1,600,000
303	90,000	280,000	220	1,500,000
304	100,000	380,000	185	1,400,000
305	80,000	460,000	150	1,300,000
306	90,000	550,000	120	1,200,000

6. HYDROLOGY.

a. Hydrology - Standard Project Floods and 10 year, 50 year and 100 year floods were developed for interior drainage Tributaries 1, 2 & 3. The Standard Project Flood hydrographs were developed by determining the runoff from each tributary during the occurrance of an SPF event generally centered over Bernville. (This is the same centering used in determing the SPF for the Blue Marsh Dam). The frequency floods (10-50-100 year) were developed from frequency precipitation as presented in U. S. Weather Bureau Technical Paper N. 40.

b. Detention Dams - Dams proposed on Tributaries 1 and 2 were designed to detain flood peaks and pass flows directly through pressure conduits into Northkill Creek. Spillways for these projects were sized by routing the SPF through each with the pressure conduit assumed blocked. These routings

developed the maximum water surface level in each pool for various sized spillways. Freeboard allowances were added to the water surface elevation to determine the top of dam elevation. To determine the effect of the proposed dams and spillways (Tributaries 1 and 2) on a Spillway Design Flood, the SDF was routed through the reservoirs with the pressure conduits assumed unobstructed. The SDF was approximated by doubling the SPF. The resulting routings indicate that the maximum pool levels would be 328.6 ft. SLD (vs. 328.4' for the SPF routing with the conduit blocked) for Tributary #1 and 322.2 ft. SLD for Tributary #2 (vs. 321.9' for the SPF routing).

c. Pressure Conduits - Pressure conduits were designed for each dam. They were sized to keep the SPF and the frequency floods below the proposed spillway crest elevation. SPF routings used in sizing the pressure conduits were done with coincident SPF elevations on the Northkill Creek. Two conditions were investigated. First the SPF was assumed coincident with Northkill Creek SPF water surface elevation when Blue Marsh Lake was at summer conservation pool level (elevation 290.0) and second with the pool level at spillway crest (elevation 307.0). Cost estimates presented above were based on the latter assumption. Pressure conduit siting for the frequency floods was accomplished by routing each flood with levels on the Northkill Creek assumed at a maximum RDF (Reservoir Design Flood) elevation with Blue Marsh Lake at elevation 307.0.

d. Ponding Area Pump Sizing - Pumping capacity to pass the SPF, 10 year, 50 year and 100 year flood events through the ponding area were developed for two criteria. One was to keep the interior drainage elevation below that which would occur naturally for a given event. The other criteria was to keep the elevation below the non-damaging elevation of 300.0. A typical performance

curve showing an SPF inflow hydrograph, the coincidental stages in Northkill Creek and the resulting ponding levels in the ponding area with an assumed pump station capacity of 300 cfs is presented in Attachment 1.

Increasing the ponding area by excavation will provide for a smoother operation of pumps and will reduce pumping requirements. For the SPF event with Alternate E in effect, pumping requirements will be reduced from 340 cfs to 290 cfs (maximum ponding to non-damaged level of 300 ft SLD) and from 120 cfs to 90 cfs (maximum ponding to pre-project flood level). The corresponding required pump capacities to handle the 100 year event are 60 cfs and 15 cfs, respectively.

7. Conclusion.

The investigations, studies, and cost estimates indicate that Alternate D (diversion of tributary #1 and #2) with ponding held at elevation 300 is the most advantageous to the government. Discussion with the local governments revealed no objection to this plan.

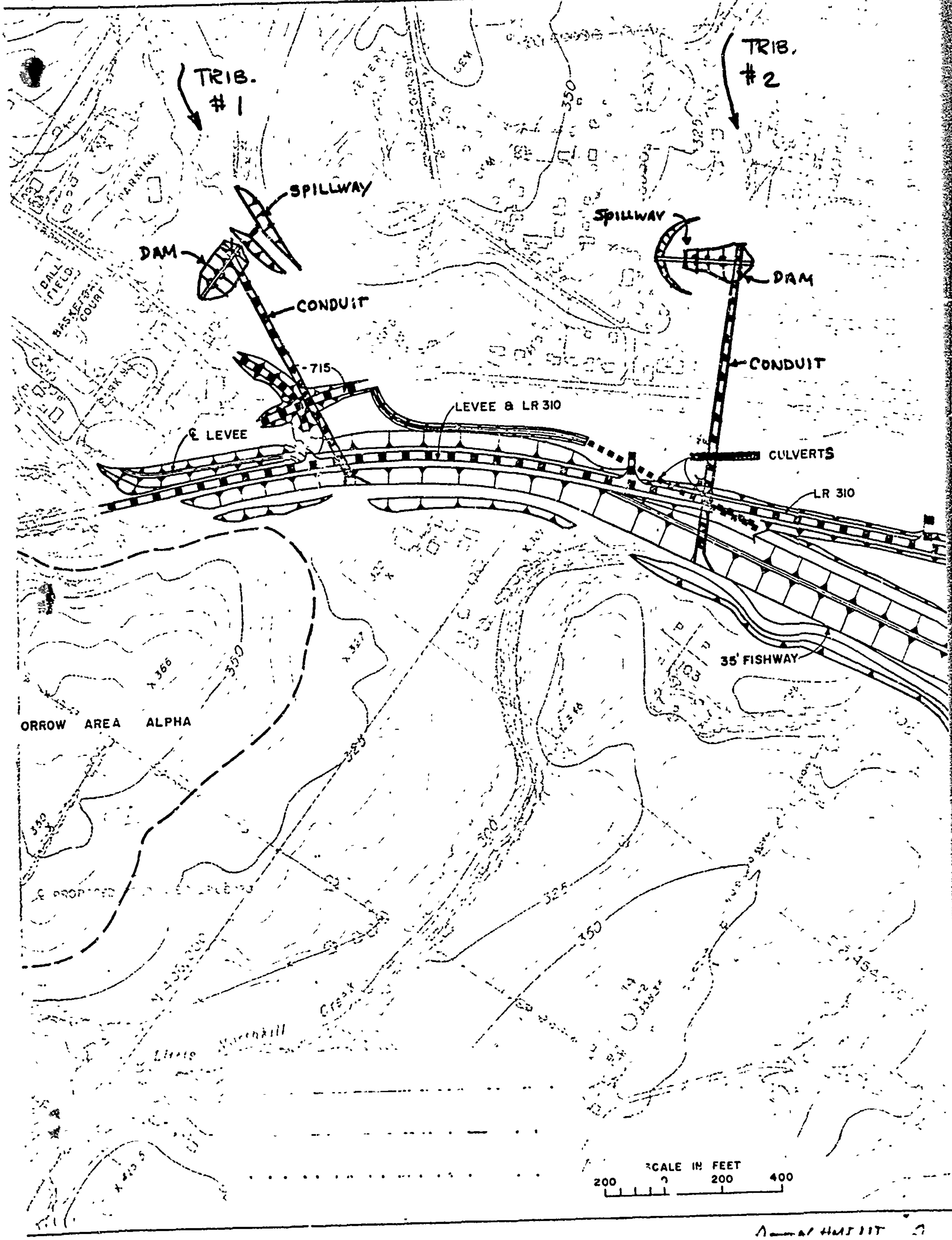
The ponding area presented in DM #13 will be enlarged through excavation and graded to drain. The increased capacity will give a smoother operation of the pumps and reduce pumping requirements. The town has indicated that it would like to use part of the ponding area for ball fields. Decision on this matter of the ball fields will be deferred pending final design.

Recommendation.

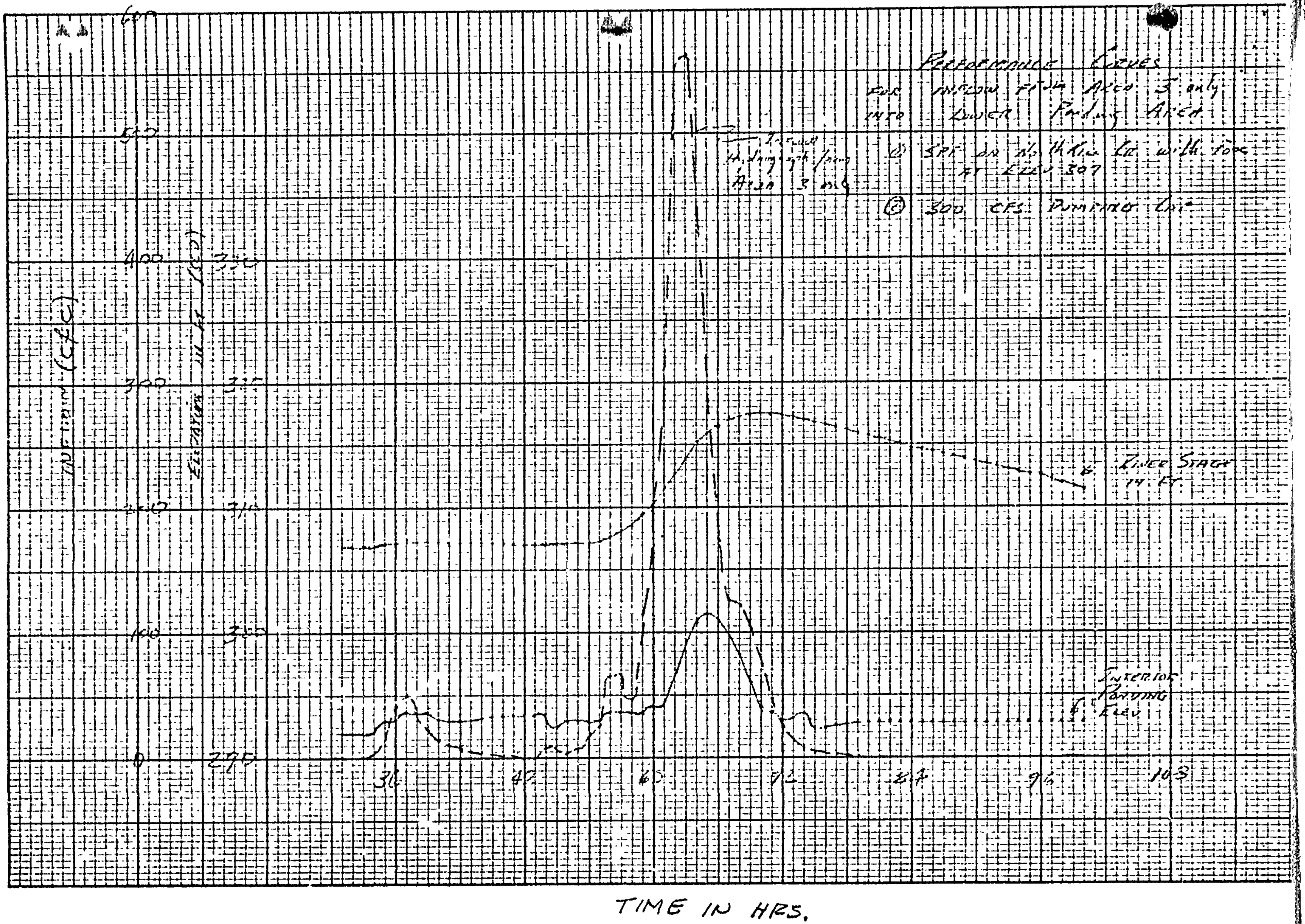
a. In accordance with ER 405-2-150 para. 8d, the construction of the protective works for the borough of Bernville necessitated by the construction of Blue Marsh Dam & Lake, will be designed to protect the Boro against an interior storm equivalent to that protection provided by the levees against

reservoir flooding (SPF).

b. Further, it is recommended that this protection be accomplished through the use of diversion of interior drainage through the levees and excavation of the ponding area in lieu of a larger pumping station. (Alternate E, see Attachment 2).



TRIB. #1
TRIB. #2
SPILLWAY
SPILLWAY
DAM
DAM
CONDUIT
CONDUIT
715
LEVEE & LR 310
℄ LEVEE
CULVERTS
LR 310
35' FISHWAY
ORROW AREA ALPHA
BALL FIELD
BASKETBALL COURT
PARKING
350
325
300
SCALE IN FEET
200 0 200 400



ATTACHMENT 1

design memorandum by OCE (premised on fee acquisition of construction areas and of reservoir lands), District and Division Engineers may recommend acquisition of flowage easements to OCE if all four of the a, b, c, and d conditions of paragraph 3 of the "Joint Policy" can be met.

(4) Lands downstream from the dam and required only for operational purposes.

c. Mineral Rights. Generally, oil, gas, and other mineral rights will not be acquired except where mineral development would interfere with the primary purposes of the project. Generally, full fee title will be acquired for the dam site and construction areas and land within a reasonable distance thereof. Exceptions to this policy must be discussed in the Real Estate Design Memorandum and be approved by the Chief of Engineers. Mineral rights not acquired will be subordinated to the Government's right to regulate their development in a manner that will not interfere with the primary purpose of the project. (See subparagraph 13a (11) as to complete treatment of mineral interests in Real Estate Design Memoranda.)

d. Reservoir Projects - Levees in Lieu of Acquisition. Where construction of levees or flood walls and necessary associated facilities for protection of lands and properties located within potential flowage limits of a reservoir is proposed in lieu of acquisition of fee title or easements over such properties, the protective structures shall meet the following minimum functional requirements:

(1) In urban communities or other areas of highly concentrated developments where overtopping of levees would result in major hazards to life or unusually severe property damage under anticipated future conditions, levee grades and designs shall be adequate to withstand without failure the occurrence of the standard project flood, assuming the reservoir is filled to the highest level that is reasonably likely to prevail at the beginning of such a flood.

(2) Under circumstances where it can be reasonably shown that possible overtopping of protective levees or flood walls as proposed would not result in unusual hazards to life or major property damage, levee grades shall be as high as economically practicable in consideration of apparent risks and costs involved, and flowage easements or other appropriate assurances from local interests shall be obtained insofar as necessary to protect the Government in the event the protective structures are overtopped.

e. River and Harbor Projects.

(1) Lands required for permanent structures, construction areas and public access areas will be acquired in fee.

(2) Permanent easements are required for channel, improvements, navigation pools, navigation aids, and disposal areas for future

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

16 JAN 1975

IN REPLY REFER TO
NAPEN-D

SUBJECT: Blue Marsh Lake Design Memorandum No. 13 - Bernville Protective Works

Division Engineer, North Atlantic
ATTN: NADEN

1. In accordance with ER 1110-2-1150, there are inclosed 16 copies of the subject design memorandum for review and approval.

2. Reference is made to NAPEN-D 3rd Ind of 7 January 1975, to NADEN-TH letter of 8 November 1974, subject, Blue Marsh Dam and Reservoir, Pa., Relocation of Highways and Bernville Local Protection. As shown on the inclosure to that letter, the award of a construction contract for protective works at Bernville is now scheduled for August 1975. In order to meet this schedule, it is imperative that review comments be received within 60 days.

3. Pending approval of D.M. 13, Bernville Protective Works, we are proceeding with the preparation of plans and specifications.

FOR THE DISTRICT ENGINEER:

1 Incl (16 cys)
As stated

for WORTH D. PHILLIPS
Chief, Engineering Division

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PENNSYLVANIA
BLUE MARSH LAKE

DESIGN MEMORANDUM NO. 13
BERNVILLE PROTECTIVE WORKS

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2d & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PENNSYLVANIA
BLUE MARSH LAKE

DESIGN MEMORANDUM NO. 13
BERNVILLE PROTECTIVE WORKS

Previous Design Memorandums

No.	Title	Date Submitted	Date Approved
1	Site Selection	31 Mar 66	7 Jun 66
2	Hydrology and Hydraulics	11 Aug 66	7 Dec 66
3	Site Geology	28 Nov 66	18 Apr 67
4	General Design Memorandum	24 Aug 67	2 Jun 69
5	Land Requirements Plan - Public Use	24 Feb 69	12 Dec 69
6	Concrete Aggregates Investigations	19 Mar 68	9 May 68
7	Real Estate	28 Mar 68	25 May 70
	Real Estate Supplement No. 1	29 Dec 71	11 Apr 72
8	Embankment and Spillway	28 Aug 68	11 Apr 69
9	Outlet Works	28 Jun 68	13 Mar 69
10	Access Roads & Oper. Facilities	27 Dec 68	20 Mar 69
11	Highway Relocations	11 Jun 74	29 Aug 74
12	Utility Relocations - Part I Atlantic Pipe Line Co.	25 Nov 68	17 Feb 69
12	Utility Relocations - Part II	14 Sep 74	
14	Reservoir Clearing	6 Aug 74	6 Sep 74

Scheduled Design Memorandums

No.	Title	Date Scheduled
15	Master Plan	FY75
16	Cemetery Relocation	FY75
17	O & M Manual	FY76
18	Reservoir Regulation Manual	FY76

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PENNSYLVANIA
BLUE MARSH LAKE

DESIGN MEMORANDUM NO. 13
BERNVILLE PROTECTIVE WORKS

TABLE OF CONTENTS

TABLES

APPENDICES

NUMBER	TITLE
A	SUBSURFACE EXPLORATIONS AND LABORATORY TESTING
B	STABILITY ANALYSIS
C	DESIGN CALCULATIONS
D	PERTINENT CORRESPONDENCE
E	ATTORNEY'S REPORT

BLUE MARSH LAKE
TULPEHOCKEN CREEK, PENNSYLVANIA
SECTION 1

PERTINENT DATA

1-01 LOCATION. The Blue Marsh Dam and Reservoir will be located on Tulpehocken Creek, a tributary of the Schuylkill River in Berks County about six miles northwest of Reading, Pennsylvania.

1-02 HYDROLOGY.

Reservoir Design Flood, elevation 307.0,c.f.s. inflow	21,300
Standard Project Flood, elevation 317.5,c.f.s. inflow	54,270
Spillway Design Flood, elevation 326.4,c.f.s. inflow	128,600
Capacity of Downstream Channel, c.f.s.	3,000
Drainage Area Above Damsite, sq. mi.	175

1-03 RESERVOIR STORAGE.

	Elevation of top of zone (ft)	Surface area (acres)	Storage Allocation (ac. ft.)
Flood Control Pool	307	2,160	50,010
Summer Season Water Supply Pool	290	1,150	22,900
Winter Season Water Supply Pool	285	960	17,620
Sediment Reserve Pool	261	323	3,000

1-04 ELEVATIONS. (ft. above s.l.d)

Top of Dam	332
Spillway Design Flood Pool	326.4
Spillway Crest	307
Top of Flood Control Pool	307
Top of Normal Pool	
Summer Season Water Supply Pool	290
Winter Season Water Supply Pool	285

1-05 DAM.

Type	Embankment
Height at Maximum Section, ft.	98
Top Width, ft.	30
Top Length,ft.	1,775
Freeboard (above spillway design flood), ft.	5.6
Embankment Volume, c.y.	776,350

1-06 SPILLWAY.

Type: Uncontrolled, unlined with concrete sill at crest	
Crest Elevation, ft.	307
Width, ft.	300
Maximum Discharge, c.f.s.	73,900

1-07 OUTLET WORKS.

Type of Conduit	Modified Oblong
Capacity at Reservoir Design Flood, Elevation 307, c.f.s.	3,980
Capacity at Spillway Design Flood, Elevation 326.4, c.f.s.	4,500
Length, bell-mouth intake to exit portal, ft.	496
Invert Elevation at Intake	237
Invert Elevation at Outlet	235
Capacity of Standard Project Flood, Elev. 317.5, c.f.s.	4,300

Gates:

Service

Type -- Slide, hydraulically operated
Number & Size -- Two, 5 feet by 10 feet

Emergency

Type -- Fixed wheel, crane operated, transferrable
Number & Size -- One, 5 feet by 10 feet

Stilling Basin Apron -- 23 feet by 55 feet.

SECTION 2
INTRODUCTION

2-01 PURPOSE AND SCOPE. The purpose of this design memorandum is to present a detailed description and analysis of the recommended plan for the Bernville protective works which will serve as a basis for preparation of construction plans and specifications. Design data and description of design procedures and criteria are contained in the subsequent technical sections. Plates showing the locations and details of structures are contained at the end of the memorandum.

2-02 AUTHORITY. The Blue Marsh Lake project was included in the general comprehensive plan for the Delaware River Basin set forth in House Document No. 522, 87th Congress, 2nd Session. The project was authorized by the Flood Control Act of 1962, Public Law 87-874, 87th Congress, dated 23 October 1962. The degree of protection for Bernville conforms to recommendations of paragraphs 1b (1) and 1c (4), 2nd Ind. NADEN-D (11 Aug 66) and as approved by 3rd Ind, ENG CW-EZ (11 Aug 66), Subject: Blue Marsh Dam and Reservoir, Pa., Design Memorandum No. 2 - Hydrology and Hydraulics and to ER 405-2-150 which outlines the use of levees in lieu of acquisition of lands in the reservoir area.

2-03 PROJECT LOCATION. The Blue Marsh Lake project is located in Berks County, Pennsylvania, on Tulpehocken Creek, approximately 6 miles northwest of the City of Reading and 1½ miles above the confluence of Tulpehocken Creek with Plum Creek. The Borough of Bernville is located on the east bank of Northkill Creek immediately upstream of its confluence with Tulpehocken Creek and about 8.7 miles upstream of the dam. The reservoir would extend to within seven-tenths of a mile from the downstream limits of the Borough when filled to the top of the normal winter season supply pool (elevation 285) and about one mile beyond the Borough when filled to the top of the flood control pool (elevation 307). See plates 1 and 2.

2-04 LOCAL COOPERATION. Meetings were held with the Borough of Bernville in 1968, 1969, 1973 and 1974 to discuss the effect of the Blue Marsh Project on the Borough and to present the plan of protection for Bernville. Responsible officials of the Borough endorsed the project and approved of the plan of protection as presented. Officials of the Pennsylvania Department of Transportation (PennDOT) have been advised of design features as they affected highways and box culverts to be altered or relocated. General concurrence has been given by PennDOT. See letter dated 23 July 1974, Appendix D, in which PennDOT issued tentative line and grade approval.

2-05 PROJECT DESCRIPTION. Features of the Bernville protective works are shown on plate 3. An alternate plan (B) and a recommended plan (A) were presented in design memorandum No. 4, the General Design Memorandum.

The recommended plan presented in this design memorandum is essentially the same as plan A except for deletion of the northern 900 feet of the levee, minor changes in the downstream channel alignment and deletion of the proposed LR 06047 bridge. The recommended plan consists of approximately 4,800 feet of rolled earth levee constructed along the left bank of Northkill Creek adjacent to the Borough of Bernville to provide protection during periods of high reservoir levels or flood stages. The levee crest will be set at elevation 320.5 except for a short reach at the upstream end which will slope to elevation 322. Pennsylvania Route 183 (LR 310) will be located atop the levee beginning near the midpoint and extending about 1400 feet upstream. About 2200 feet of the Northkill streambed will be realigned across the right bank flood plain. A 350-foot-long saddle dike will be provided just downstream of the levee to prevent flanking during extreme flood conditions. A 360,000 g.p.m. storm-water pumping station will be provided near the downstream end of the levee to evacuate the interior drainage runoff from three unnamed tributaries (areas 1, 2 and 3) and intermediate areas intersected by the dike, during high stages on Northkill Creek, see plate 33. A gated gravity outfall structure will be constructed through the levee adjacent to the pumping station to pass interior drainage at all other times. The ponding area will be provided adjacent to the levee to collect runoff from areas 1 and 2, local runoff from storm drain outfalls, and seepage. A system of ditches will be constructed adjacent to the landside toe of the levee to collect the runoff and pass it to the ponding area and from the ponding area to the pumping station. Culverts will be provided beneath Pennsylvania Route 183 (L.R. 310) where it will ramp onto the levee to connect the upstream and downstream ditch system. Runoff from the watershed of area No. 3 will drain directly to the pumping station area.

Adjacent to the downstream end of the levee, where Pennsylvania Route 183 (L.R. 310) cuts through the high ground, a point below the levee crest will occur at approximate elevation 318. Consideration was given to raising the highway through the cut to eliminate the low area. A study for raising the highway in accordance with PennDOT criteria was made and the resulting construction cost, exclusive of real estate requirements, was determined to be approximately $250,000. In view of the cost and the fact that portions of Route 183 (L.R. 310) outside the Bernville protected area are below elevation 318.0 and will become impassable at the levee design stage, raising the highway is not considered justifiable and it is recommended that a temporary closure be made in the event that design stage is reached. The area to be closed will fall in the freeboard range and can be readily sandbagged to elevation 321. A sufficient number of sacks will be stored nearby in the pumping station. Instructions and procedures to be followed will be included in the Operation and Maintenance Manual.

2-06. DEPARTURES FROM THE PROJECT PLAN.

General. The project plan, as presented in Design Memorandum No. 4 General Design Memorandum (the G.D.M.), had to be modified as noted below:

a. The relocation of Pa. Route 183 (L. R. 310, Segment 6) is longer than initially anticipated. Also, additional side road access to Route 183 and ramps are now necessary. The changes are required by the Pa. Department of Transportation (PennDOT), and detailed analysis of the plan coupled with detailed surveys.

b. PennDOT's current highway criteria requires widening of the levee crest (for the highway portion of the levee) from the planned 48 feet to 60 feet. Also, relocation of an additional portion of Northkill Creek is necessitated.

c. A second borrow area is provided to assure an adequate supply of impervious fill.

d. When the General Design Memorandum was prepared, it was known the Borough of Bernville intended to construct a sewage treatment plant. This plant was to be located within or adjacent to the ponding area. As the exact plant location was unknown, a definitive design and costing of the interior drainage system and the ponding area with its resultant effect upon the pumping plant was excluded from the General Design Memorandum. The sewage treatment plant is now built and it alters the ponding area capacity. Additionally, concrete flood walls will have to constructed to protect this facility. Other items are similarly affected. (The discussion and the comparison of current cost estimate with the project cost estimate amplify this situation.)

e. The pumping plant capacity requirements have increased from 200,000 g.p.m. to 360,000 g.p.m. principally as a result of the decreased ponding area and more detailed hydrological studies.

f. A new power line is required to furnish a reliable and adequate power supply for the pumping plant. Presently, sufficient power is not available in the vicinity of the pumping plant.

g. The real estate project take line has been revised to reflect the necessary design changes.

SECTION 3
ENVIRONMENTAL ENHANCEMENT

3-01 EXISTING CONDITIONS. The Bernville protective works, including ponding areas and flood-prone easements, lies in the flood plains of Northkill Creek and the Blue Marsh Lake Project. That creek generally parallels the southwest edge of the Village of Bernville, approximately on the line of the protective works, and is a tributary of Tulpehocken Creek. Pennsylvania Route 183 (L.R. 310) parallels the northeast side of Northkill Creek and generally acts as the perimeter of the Village of Bernville.

a. Structures in and adjacent to the project area consist of numerous residences, some small business establishments and a school. On the southwest side of the dike, the land is primarily agricultural and woodlands. There is no manufacturing of consequence in the area. Within the project boundary some residences and small business structures and properties will be purchased and the structures removed. According to the Pennsylvania Register of Historic Sites, there are no historically significant structures in the project area. However, the Bernville Hotel, Northkill Covered Bridge and the remains of Lock 36 of the Union Canal may be considered possible sites of local historical significance. The possibility of salvaging stone and iron from the lock and significant artifacts from the hotel and bridge are being considered in developing an interesting exhibit in the Blue Marsh project area.

b. The protective works project is in the oak-yellow poplar general forest region with 50% to 74% of the county being forested. An inventory of plant species in the immediate vicinity of the protective works is in table 1.

Table 1
Inventory of Plant Species

<u>Deciduous Trees.</u>

Ailanthus altissima - Tree of Heaven

Acer platanoides - Norway Maple
Acer rubrum - Red Maple

Acer saccharinum - Silver Maple

Betula sp - Birch
Carya Sp - Hickory
Catalpa speciosa - Northern Catalpa
Fraxinus pennsylvanica- Green Ash
Gleditsia triacanthos - Black Locust
Juglans nigra - Black Walnut
Malus pumila - common Apple
Platanus occidentalis - Sycamore

Prunus serotina - Black Cherry
Quercus palustris - Pin Oak
Salix nigra - Black Willow

<u>Coniferous Trees.</u>

Juniperus Virginiana - Eastern Red Cedar
Picea abies - Norway Spruce
Pinus strobus - White Pine
Pinus sylrestris - Scotch Pine

<u>Shrubs and Vines.</u>

Hemorocallus fulva - Common Daylily

Lonicera Sp. - Bush Honey - suckle
Lonicera japonica - Japanese Honeysuckle

Parthenocissus quinquifolia- Virginia Creeper
Shus sp. - Sumac

Rubus strigosus - Wild Raspberry

Toxicodendron radicans - Poison Ivy

c. The fish and wildlife populations in the project area are associated with Northkill Creek, its flood plain and the cultivated higher lands west of the creek.

1. The creek fishery upstream of the project area is enhanced by both pre-season and in-season trout stocking by the Pennsylvania Fish Commission. The high quality and low temperature of the water is particularly conducive to a sustained trout fishery and some rare native brook trout have been identified in the creek. Included in the warmer shallows and still water portions of the creek are limited numbers of minnows, pumpkin seed, sunfish, dace, shiners and an occassional small mouth bass. The still water areas are the result of two small dams which will be removed in construction of the dikes.

2. Indigenous wildlife species are essentially divided by habitat and environment into upland and flood plain group. The flood-

plain dwelling species are characterized by wetland and water oriented environments while the upland species are associated with cultivated fields and forest habitats. A partial inventory of typical species in both categories is included in table 2.

Table 2
Inventory of Wildlife Species.

Phasianus colchicus - Ring-necked Pheasant
Sylvilagus floridanus - Cottontail Rabbit
Vulpes fulva - Red Fox
Odocoileus virginianus - white tailed Deer
Colinus virginiana - Bobwhite
Marmota monax - Woodchuck
Sciurus carolinensis - Gray Squirrel
Bonasa umbellus - Ruffed Grouse
Procyon lotor - Raccoon
Ondatra zibethicus - Muskrat
Ambystoma sp. - Salamander
Rana sp - Frog
Bufo sp. - Toad
Chelydra serpentina - Common Snapping Turtle
Terrapene carolina - Eastern Box Turtle
Various common snakes and typical bird species including robins, starlings, wrens and occasional migrating waterfowl.

d. Land use in the immediate project area is divided by the existing highway right-of-way and creek and consists primarily of the small businesses and residences on the town side of the creek and more rural open lands of residences and small farms on the other side. Tax-ratable land loss to the community resulting from the protective works is less than approximately 5% and will likely be returned by relocation in other parts of the community of many of the individuals displaced. 1/

1. Recreational use of Northkill Creek in the vicinity of Bernville is presently limited because of the proximity of the highway, businesses and the village. There is a three-acre park for picnicking and associated stream access which will be partially lost due to construction.

3-02 ENVIRONMENTAL IMPACTS OF THE PROTECTIVE WORKS. Generally the beneficial aspects of the construction have been recognized and quantified. The benefits of flood control are enhanced by the security provided in developing regional expansion plans and in stabilizing regional economic and local property values. In addition, the Blue Marsh Project, on the whole, will play a major role in the development of approximately 300 acres of residential land in Bernville and in sections of Penn Township adjacent to the Borough. Also, Bernville

1/ Trends observed at the Bernville Real Estate Office for the Blue Marsh project.

should develop a larger business district which will serve the needs of the increased numbers of residents and a specialty market related to the Blue Marsh project. 1/ The upgrading of Rt. 183 (L.R. 310) by widening and relocation will determine feasible sites for private commercial-recreational facilities. The development of the Blue Marsh Lake project will provide residents with easy access to a regional park, and this may help to offset the impeded access to Northkill Creek by the levee. The impacts addressed below are those effects which will be detrimental to the natural characteristics of the area, and by utilization of the lands previously described for the protective works construction.

a. The protective dike paralleling the southwest side of Bernville will present a new land form inconsistent with the character of the area. The barrier will impede recreational access to Northkill Creek which will be relocated to accommodate the dike.

b. Realignment of approximately 2100 feet of the Creek channel and approximately 300 feet of other bank adjustments will be disruptive to the fishery habitat and present a sterile environment for the passage of fish.

c. Vegetative cover and wildlife habitat will be lost. The msot seriously affected wildlife population will be the wetland species unable to migrate rapidly or which live or seek protection in soils being displaced. Land-based animals and water-oriented species better adapted to migration will find adequate similar habitat nearby. The aesthetic attributes of the vegetation and its mechanical effects on the climate will be lost.

d. Borrow areas will be created which will further degrade regional character.

e. Construction noise, river turbidity and traffic congestion will be short term annoyances. Disruption of surface drainage patterns will occur in the residential areas of Bernville.

f. Disruption of park continuity will occur.

3-03 PROJECT ENHANCEMENT. Devices to minimize the impacts of the protective structures will not totally restore area aesthetics or quality. However, the project modifications and enhancements shown on plates 28 through 31 and discussed below can make acceptance of the protective works more compatible with the environment and public uses. Inclusion of the measures discussed will increase project costs,however, much of that cost can be accounted for in various categories of anticipated constrution cost estimates. Those anticipated costs include roadside planting, general landscaping, erosion control and fishery enhancement.

1/ Trends observed at the Bernville Real Estate Office for the Blue Marsh project.

a. Construction design and contractural restraints similar to those cited in ER 1165-2-500 and CE Guide Specification No. 1300 will minimize the effects of actual construction including ercsion control and temporary nuisances.

b. Roadside planting will be included in the vicinity of relocated Pennsylvania Highway 183 (L.R. 310) in accordance with criteria provided by the Pennsylvania Department of Transportation. Additional landscaping will be installed in areas adjacent to ponding areas, residences and in conjunction with recreational accesses. Utilization of planting guidelines in ER 1110-2-301 are not applicable to this project due to limited construction space and restraints imposed by state and other criteria.

c. A trail system will be developed on top of the portions of the dike unencumbered with the highway and extended into recreational area.

d. Fishery enhancement will be provided in the relocated channel by including the refinements suggested by the Pennsylvania Fish Commission and outlined below. See plates 5 through 8, 12 and 13.

(1) Subchannel for low flow requirements.

(2) Random placement of large boulders in a stream bed to provide fish rest places and deep holes.

(3) Changes in shoreline bank heights and variations of stream widths.

(4) Meandering alignment wherever possible.

e. Provisions for recreational access to Northkill Creek for fishing, hiking and picnicking will be provided by extending the remaining portion of the existing park into new adjacent areas.

SECTION 4

GEOLOGY, SOILS AND LEVEE EMBANKMENT

4-01 GENERAL GEOLOGY. The Bernville Protective Works lies in the shale uplands portions of the Great Valley Section of the Appalachian Valley and Ridge Physiographic province. In the project area, the terrain resembles a dissected plateau and it is characterized by northeast-southwest trending hills which rise 150 to 200 feet above the main stream valleys. The area is underlain by the Upper Ordovician, Martinsburg formation which consists of highly folded shale with some interbedded limestone, siltstone and sandstone. Surface mapping and research of the literature indicate the Martinsburg formation is folded into a series of northeast-southwest trending anticlines and synclines. Bedding and cleavage strike northeast-southwest and dip variably 20 to 85 degrees southeast with the average dip being about 50 degrees. A closely spaced set of tension joints strike parallel to the cleavage and dip 20 to 60 degrees northwest. Scattered vertical joints strike in a north-south direction.

4-02 SUBSURFACE INVESTIGATIONS. A total of 33 borings and 20 test trenches have been made under three phases. Sampling of soils and rock was performed in borings and test trenches located in structure foundations and borrow sources; namely, protective works levee -14 borings and 2 test trenches, relocated creek -3 borings and 2 test trenches, pumping station -6 borings and 1 test trench, flanking levee -1 boring, borrow area Alpha -5 borings and 4 test trenches, borrow area Bravo -8 test trenches, alternate borrow areas -3 test trenches. Undisturbed samples were taken in three borings, one in the pumping station foundation and one in each of the main and flanking levee foundations. Classification, compaction, triaxial compression, direct shear and permeability tests were made on representative soil and weathered rock samples from selected borings and trenches. Sampling in borings consisted of $3\frac{1}{2}$" O.D. split spoon samples in overburden and NX (2 1/8") cores in bedrock. Test trenches were made with a backhoe. Phase I was conducted during May of 1966 for purposes of General Design. Eight borings and 3 test trenches were made in or adjacent to foundation structures and 5 test trenches were made in borrow sources. Phase II was conducted during November 1973. Sixteen borings and 12 test trenches were made to obtain additional information for detailed design of structures and borrow sources. Phase III was conducted during October 1974. Nine borings were made to further define structure foundations. Explorations are shown in plan on plate 4. Logs of explorations and results of laboratory tests appear in appendix A on plates A1 through A12.

4-03 SITE SOIL CONDITIONS. The character of the soils are shown on profiles along the main levee, flanking levee, borrow areas and logs of explorations. See plates 9, 10, 11 & 15 and A1 through A4 respec-

tively. Residual soils developed from insitu weathering mask the bedrock in the upland areas. They overlie the bedrock on the borrow areas and abutments of the main levee and flanking levee. Alluvium deposited by streams mantles the bedrock in the valley bottom crossed by the main levee, creek relocation and low areas of the saddle crossed by the flanking levee.

Residual soils consist mainly of gravel to sand size, angular, shale fragments with a trace to some silt and clay. The residual soils are mantled with 0 to 1 foot of topsoil and extend variably to depths of 0.5 to 10 feet. The amount of fines tend to decrease with depth as the residuum grades from soil to bedrock. Residual soils developed on upper slopes underlain by shales as in borrow areas Bravo tend to be shallower and have a lesser amount of fines than those developed on upper slopes underlain by limey areas as in borrow area Alpha. The shale and limey shale bedrock underlying the borrow areas is weathered to depths up to 20 feet to the extent that when excavated with a backhoe, the material has the consistency of coarse gravel. When placed and compacted in a fill, the gravel size fragments are broken down to smaller sizes and an appreciable amount of fines are produced. Alluvium is predominantly fine grained but variable in composition; thin layers of clay, silt, silty sand and gravel occur erratically throughout the flood plain. The alluvial deposits range in thickness from 0 to 10 feet on the Northkill Creek floodplain crossed by the main levee and 0 to 16 feet on the flood plain of the unnamed creek crossed by the flanking levee. The alluvium is highly variable in permeability and subject to large seasonal variations in moisture content and is susceptible to softening under normal foundation preparation and construction operations. Fill materials consisting mainly of silty gravel also occur on the flood plain. They appear mainly as road fills up to 12 feet above the alluvial plain as in Pa. route 183 which parallels Northkill Creek in a northwest-southeast direction.

4-04 GROUNDWATER. The groundwater levels vary considerably, however, the groundwater surface generally conforms with the topography and slopes toward valley bottoms. Thus it is expected groundwater will flow toward the streams. Along the floodplain of Northkill Creek where the main levee and most other structures are founded, the groundwater is at or within 5 feet of the natural ground surface. On the upland areas where borrow areas are located, the groundwater is generally deep and is contained in fractures of the relatively impervious bedrock. Groundwater was not encountered in borrow area Alpha to a depth of 29 feet. Groundwater was encountered at 12.0 feet in a test trench located on the lower slope of the hillside in borrow area Bravo. Groundwater is at the surface in the lower foundation area of the flanking levee which occurs in an upland valley

between two sloping hillsides.

4-05 LEVEE EMBANKMENT DESIGN.

a. Alignment. The main levee as shown on plates 5 through 8 begins from high ground on the western corner of the existing school property, approximately 100 feet northeast of LR 310. The levee trends southeast paralleling LR 310 alignment, for approximately 700 feet, until the rising roadway grade from existing concrete bridge over Northkill Creek brings the LR 310 roadway up to the required level of protection. From this point, the levee and embankment of relocated LR 310 are merged for approximately 1000 feet to provide the needed protection. At station 26+60, the levee separates from the relocated highway and trends southeast in a straight line for about 2400 feet to form the left bank of relocated Northkill Creek. This straight alignment results in two levee crossings over the existing meandering creek. At station 51+00, relocating of Northkill Creek ends and the final levee alignment has been set to parallel the existing creek on the left bank until termination at the high rock knoll at the southern end of Bernville.

b. Cross Section. The main levee section as shown on plates 12 and 13 will consist of central impervious core with outer shells of random fill. Levee side slopes will be 1V on 2.5H for the landside and 1V on 3H for the riverside slope except for a 350-foot stretch of 1V-on-2H riverside slope where the levee also serves as part of relocated LR 310. The 1V-on-2H riverside slope will be free draining to improve stability by requiring placement of granular alluvial materials or rockfill from required excavations in the outer shell. This steeper slope is necessary to minimize the placement of fill into existing Northkill Creek and to reduce the amount of rock excavation required for creek widening. The levee top width will be 10 feet and the levee will have a maximum height of approximately 30 feet which includes 3 feet of freeboard under standard project flood conditions. The top elevation of levee will range from el. 322 at upstream end to el. 320.5 except for the portion where vertical grades to accommodate LR 310 result in elevations higher than the required protection.

c. Foundation Conditions. The levee is founded principally on the flood plain of Northkill Creek. The levee alignment is opposed to the northeast-southwest strike of geologic structure and stratigraphy and thus traverses diverse lithologies. Foundation materials and bedrock conditions are shown in profile along the centerline of the levee on plates 9 and 10. Alluvium covering the valley bottom varies from 0 to 10 feet deep with the average depth being about 6 feet. As indicated on the profile and borings, some flood plain alluvial soils include soft clays up to a maximum depth of 5 feet which will be excavated within the levee foundation and wasted. Most

of the alluvium consists of interlayered zones of fines and poorly graded sands and gravels with varying amounts of fines. The detritus making up the materials has been derived from the weathering of shale, quartzite, sandstone and limestone with shale being the chief parent rock. Gravel, cobbles and boulders consisting of quartzite, sandstone and some shale are concentrated in the lower part of the alluvium in contact with the bedrock. This zone is quite pervious and excavations through it will encounter high rates of seepage inflow. Bedrock underlying the northern 1,600 feet of the levee is interbedded Martinsburg limestone, shale and sandstone. The remaining portion of the levee is underlain chiefly by red and green shale. Some yellow-brown and gray shale interbedded with green and red shale underlie the southern 400 feet of the alignment. An outcrop of grey and brown shale occurs in the downstream terminus (abutment) with firm rock virtually at the surface, while bedrock in the upstream terminus (abutment) appears to be covered with 2 to 4 feet of residual overburden. In most of the valley bottom, firm rock is virtually in contact with the alluvium and severe weathering of bedrock extends to depths of only 1 to 3 feet. However, in the southern 400 feet of the alignment where the pumping station is located, severe weathering of the bedrock extends variably to depths up to 10 feet. Prominent fracturing in all foundation bedrock is parallel to the cleavage which strikes north 55 to 80 degrees east and dips 32 to 75 degrees southeast. The arrangement of fracturing is normal to the strike of the levee. However, most of the fractures appear to be tight and no seepage problems through the bedrock are anticipated for the proposed hydrologic conditions. Groundwater varies from 0 to 4 feet below the natural ground surface. In the southern half of the alignment, the alluvium is saturated and groundwater is at or within a foot of the surface most of the year. As stated in paragraph 4-04, the tendency of groundwater is to conform with topography and thus it is expected groundwater as well as surface runoff will be from the surrounding hills toward the valley bottom.

d. Seepage.

1. Underseepage. Seepage through the foundation will be controlled by excavating a cutoff trench to weathered rock and backfilling with impervious fill. The cutoff trench will be excavated along the total length of levee to a bottom width of 10 feet with 1V-on-1.5H side slopes. The maximum depth of excavation is estimated at 16 feet near Station 15+35, but generally averages between 5 to 8 feet in depth. The cutoff trench depth will be extended into weathered rock in locations where the upper rock surface is fragmental and considered pervious. Grouting of rock below this level is not considered necessary because of the moderate pool levels of infrequent and short duration to be imposed on the levee.

2. Through Seepage. An approximate estimate of through seepage indicates the quantity of seepage through the impervious fill will be small. Any seepage which permeates the core and semi-pervious random fill zones should be intercepted by the interior drainage ditch which parallels the levee. Surface and through seepage waters collected in the interior ditch whose grade closely approximates the existing creek will flow by gravity to the pumping station area.

e. Stability Analysis. Slope stability analyses at two levee locations were performed using the Modified Swedish Method (Computer programs 41-Z5-104G and 741-F5-E503B) with occasional manual checks. The adopted method is in conformance with EM 1110-2-1902, "Engineering and Design, Stability of Earth and Rock-fill Dams" dated 1 April 1970. The only departure from EM 1110-2-1902 criteria was in the use of the side earth force direction, where, rather than use the suggested average outer slope as the side force direction, a direction was adopted which was the average of the outer slope and the slope of the failure plane at the base of each slice. This departure was made because experience has indicated unreasonable results are obtained when only the average outer slope direction is used for circular failure surfaces having short radii just above the outer embankment surface. A detailed discussion of the analyses is included in appendix B. The lowest factors of safety obtained in the stability studies are summarized in the following table:

STABILITY SUMMARY

Case	Slope	Strength	Safety Factor	Safety Factor for Earthquake
	1V on 2H Riverside		1.60	
Sudden Drawdown From el. 307	1V on 3H Riverside	S or R	1.40	-
	1V on 3H Riverside		1.65	1.38
Partial Pool	1V on 2H Riverside	S or $\frac{S+R}{2}$	1.50	1.30
After Construction	Landside	Q	2.17	1.86
Steady Seepage	Landside	S or $\frac{S+R}{2}$	1.50	1.30

f. Settlement. Settlement due to consolidation of the foundation will be negligible because of the normally shallow depths of relatively dense overburden materials above competent bedrock. As discussed in paragraph 4-05. c., the soft, compressible, fine grained, alluvial soils within the levee foundation will be removed and wasted. Significant settlement within the low levee embankment section is

considered unlikely because of controlled placement and compaction requirements; therefore, no overbuild for settlement is considered necessary.

g. Slope Protection. The need for slope protection against eroding channel flows was evaluated using criteria in EM 1110-2-1601. Backwater computations showed that the 100-year event caused the most severe conditions of eroding velocities and depths and thus controlled the design rather than Standard Project Flood conditions. The basis for establishing the level of protection shown on the sections for the ri[illegible] slope is discussed in paragraph 5-02e. Riprap to be placed or [illegible] [illegible]rside levee slope which forms the left bank of Northkill [illegible] range in thickness from 12 to 27 inches and will be keyed [illegible] the levee toe to a minimum depth of 3 feet below streamed level, except where firm rock forms the bottom of Northkill Creek. The curving right bank of Northkill Creek directly downstream of existing LR 310 bridge will be protected with 27-inch riprap for approximately 140 feet until the stone protection is terminated into the existing rock slope. The 1V-on-3H slope in overburden on the right bank beyond the rock slope will have protection limited to topsoiling and seeding. Slope protection to resist wave action was designed using guidelines presented in EM 1110-2-2300. An 18-inch-layer thickness of riprap is required from station 53+50 to the downstream end of levee based on a 72-mile-per-hour wind velocity over reservoir pools for an effective fetch of 6,200 feet. Upstream of Station 53+50,the narrow valley containing Northkill Creek restricts the length of fetch which can develop wind-generated waves against the levee slope; therefore, the required protection in this area is controlled by creek velocities. The area requiring protection against wave action will have riprap extending from the levee toe to elevation 311, which is 4 feet above spillway crest elevation 307. Specifications will require the riprap to be placed to its full thickness in one operation and will be required to be well graded within the gradational limits presented on plate 14. Bedding layers where required, shall be 6 inches under 12-inch riprap and 12 inches beneath all other riprap sizes. Borrow areas and all other areas disturbed by construction will be seeded in addition to the topsoiling and seeding of the main leve[illegible] landside slope and riverside slope portion above required riprap l[illegible]el.

h. Flanking Levee.

(1) General. The flanking levee as shown on plate 11 closes a narrow valley on the southside of Bernville. The flanking levee extends in a north-south direction for approximately 350 feet and has a top elevation of 320.5. The maximum height is about 22 feet above the lowest existing ground elevation and the flanking levee is similar to the main levee in cross section and internal zoning as shown on plate 13. A 5-foot-deep inspection trench backfilled with impervious fill has been required to insure adequate seepage control. The lowest level of existing LR 310 which forms the boundary of Blue Marsh reservoir approximately 900 feet southwest of the flanking levee,is

elevation 310; therefore, reservoir pools will only reach the flanking levee at frequencies greater than the 100-year spillway flood. Because of the infrequent and short duration of pools above elevation 310 and the low velocities resulting from flows under Standard Project Flood conditions, stone protection on the flanking levee slope is not considered necessary. Topsoiling and seeding on both landside and reservoir side slopes will be required.

(2) Foundation Condition. Foundation conditions are shown in profile on plate 11. The flanking levee is located in an upland valley between a hill to the north containing the downstream terminus (south abutment) of the main levee and a hill to the south containing borrow area Bravo. An unnamed intermittent, low gradient stream fed by groundwater flowing from the adjacent hillsides extends in an east-west direction through the center of the valley. The 200-foot-wide valley bottom is masked with alluvium up to depths of 19 feet. Boring SAB-23 indicates the alluvium consists of interlayered clay, silt, silty-clayey sands and silty gravel with the silty gravel in contact with weathered shale. Groundwater is at or near the surface in the valley most of the year and the valley bottom is soft and marshy over most of its width. Residual overburden, consisting of sand and gravel size, shale fragments with varying amounts of fines, overlie shale bedrock in the abutments. Test trenches in nearby borrow area Bravo indicate the residuum varies in depth from 2 to 10 feet.

4-06 CREEK RELOCATION.

a. General. Northkill Creek will be relocated west of its present location for a length approximately 2,500 feet long to provide ponding capacity for interior drainage collected behind the main levee. The proposed realignment is essentially the same as shown in the General Design Memorandum. Upstream of the relocated portion, the creek will be shifted slightly southwest into the existing right bank to compensate for the lost flow capacity resulting from encroachment of LR310 embankment fill into the creek because of raised roadway grade. As shown on plates 5 and 6, a 40-foot minimum bottom width for Northkill Creek is held above the confluence with Little Northkill Creek to improve flow conditions by elimination of constrictions that would result in higher velocities. Several large sized boulders that are intended to provide stillwater resting locations for fish in Northkill Creek will be placed at 50-foot intervals along the strength where shifting of creek is necessary. The boulders will be restricted within a 10-foot zone at toe of excavation on right bank at low levels that will have little influence on flow conditions during high water stages. Downstream of station 32+00 along the relocated portion of Northkill Creek a minimum 70-foot bottom width will be held. In an effort to accommodate requests from the Pennsylvania Fish Commission to duplicate natural flow conditions, the relocated creek was established with a curving alignment that was influenced by existing topographic features and ease in excavating materials, particularly in the low flood plain area.

b. Foundation Conditions. The flood plain crossed be relocated Northkill Creek is mantled by 5 to 6 feet of alluvium consisting of interlayered silt, clay, silty sands and gravel. The underlying bedrock consists of red and green shales with firm rock being 1 to 2 feet below the alluvium-weathered rock interface. Relatively firm shale is at the surface in the creek bottom and south creek bank where the creek relocation departs from its normal course. Groundwater is at or near the ground surface over most of the creek relocation alignment.

c. Hydraulic Design. Various channel widths were examined to determine the optimum channel size at minimum cost. The 70-ft bottom width channel (plates 6 through 8) will contain generally a 50-year flood water surface elevation within banks. The velocities developed during the 100-year flood require only minimum 12-inch riprap protection. A larger channel would decrease velocities enough to eliminate riprap, but the additional cost of real estate acquisition would make this alternative uneconomical.

d. Side Slopes. Side slopes along relocated Northkill Creek channel will be 1V on 3H. Upstream of the relocated portion where the creek will be shifted slightly southwest, levee slopes forming the left bank will transition from 1V on 3H to the steeper 1V on 2H slope for reason discussed in paragraph 4-05.a. Excavation slopes on the right bank will be 1V on 1H in rock, 1V on 2.5H in weathered rock and residual overburden, and 1V on 3H for excavated slopes in the finer flood plain alluvial materials.

4-07 CONSTRUCTION MATERIALS.

a. General. Materials required for construction of the main levee and flanking levee embankments will mostly be obtained from borrow areas Alpha and Bravo with smaller quantities available from required excavations in the cutoff trench, relocated creek area and structure foundations. The borrow areas are favorably located at each end of the project as shown on plate 3. Topsoiling and seeding will be required on final excavated surfaces which will be graded to drain and blend with the adjacent terrain.

b. Impervious Fill. Impervious fill consisting of lean clays and silty and clayey sands which will be required to have not less than 25% passing the 200-mesh sieve can be obtained from both borrow areas at depths averaging 7 feet up to a maximum 15 feet. The better quality impervious fill containing more plastic fines is available in borrow area Alpha from the residual soils of limey bedrock. Impervious fill quantities available in Alpha and Bravo are estimated to be 190,000 c.y. and 34,500 c.y., respectively. The required volume of impervious fill is estimated at 92,000 c.y.

c. Random Fill. Random fill will consist of clayey and silty sandy gravels, and sandy gravels with little fines from required excavations and the borrow areas. It is estimated that 370,000 c.y. of random fill are available in borrow area Alpha and approximately 177,000 c.y. in borrow area Bravo. The required volume of random fill is 276,300 c.y. In placing random fill, the more impervious materials will be placed towards the inner portion of this zone, adjacent to the impervious fill.

d. Rockfill. Firm rock excavation for the relocation of Northkill Creek will provide the small 3600-c.y. volume of rockfill needed in the levee embankment.

e. Fill Placement Compaction. Lift thickness will be 8 inches for impervious fill and 12 inches for random and rockfill materials. Each lift will be compacted by 4 passes of a 50-ton pneumatic roller except rockfill which will be compacted by 2 passes of a D-8 or equivalent crawler-tractor.

f. Stone Protection. Good quality material for the total 19,400 c.y. of required stone protection can be obtained from commercial sources within a range of 15 to 20 miles from project site.

4-08 INSTRUMENTATION. Several Casagrande open-type piezometers will be installed within the main levee foundation near the landside toe to measure water pressures resulting from intermediate flood pool levels on the completed structure. Measured pressure will be used to evaluate the effectiveness of the cutoff trench and for comparison with design assumptions.

SECTION 5
HYDROLOGY AND HYDRAULICS

5-01. HYDROLOGY.

a. General. The Town of Bernville shares the general hydrologic patterns developed for the Blue Marsh Lake project and discussed in Blue Marsh Lake DM No. 2, Hydrology and Hydraulics. Specific further hydrologic investigations are discussed below.

b. Climatology. The representative climate for the Tulpehocken Creek Basin is listed in Section 3, Blue Marsh Lake DM No. 2, Hydrology and Hydraulics.

c. Watershed. The Bernville area is located within the Tulpehocken Creek Watershed and is therefore subject to all natural effects associated with that general area. A description of the Tulpehocken Creek Basin can be found in Section 4, Blue Marsh Lake DM No. 4, General Design Memorandum. Also, a general basin description is presented in Section 3, Blue Marsh Lake DM No. 2, Hydrology and Hydraulics.

d. Unit Hydrographs (Interior Drainage). Unit hydrographs for the three tributaries contributing to the Bernville interior drainage were developed synthetically by both the Snyder and the appendix M (House Document 522) methods. The Snyder Method gave more conservative results and therefore was adopted. Values for Cp640 and Ct were taken as 225 and 1.0 respectively. These values were based on values derived from an analysis of streamflow record of the Tulpehocken Creek gage near Reading, Pennsylvania and modified to insure conservative results for peak discharge. Drainage areas of the three tributaries are delineated on plate 33. Half-hour unit hydrographs for the three tributaries are also shown on plate 33.

e. Standard Project Storm. The design of the protective works at Bernville is based on the Standard Project Storm as developed in Blue Marsh Lake DM No. 2, Hydrology and Hydraulics. The Standard Project Storm index rainfall over the Blue Marsh Project area was 12.18 inches. The average depth of rainfall on the Northkill watershed above Bernville was 13.80 inches during the Standard Project Storm. Rainfall excesses were applied to the unit hydrograph to produce the Standard Project Flood hydrograph. This hydrograph was routed through the reservoir assuming various antecedent conditions. Water surface profiles were computed (using HEC II Water Surface Profile Program) for the Standard Project Flood flows with coincidental conditions, as discussed in "Coincidental Conditions" below. The composite water surface profile thus derived was used (with proper freeboard added) to arrive at design height for the Bernville Protective Works levees. Further details on Standard Project Flood derivation are found in Blue Marsh Lake DM No. 2, Hydrology and Hydraulics.

f. Flood Frequencies. Flood frequencies for the Bernville Interior Drainage are based on rainfall intensity duration curves from U. S. Weather Bureau Technical Report Nos. 40 and 49 (plate 34): "Rainfall Frequency Atlas of the United States." Point values interpolated from the isohyetal maps are tabulated on plate 33. Rainfall frequency duration curves were developed from the point values and are shown in tabular form on plate 33 and on plate 34. Flows of various frequencies were determined by application of rainfall excess amounts to the unit hydrographs.

g. Design Storm. The design storm used in sizing the gravity outfall for the Bernville interior drainage is a 25-year frequency storm (4.08 inches of precipitation) with a 6-hour duration. The rainfall hyetograph was developed by the method presented in EM 1110-2-1410, "Interior Drainage of Leveed Urban Areas: Hydrology," appendix C, and is shown on plate 33. An initial rainfall loss was taken as 0.5 inches and an infiltration rate was taken as .05 inches per hour. Excess rainfall increments were applied to the unit hydrographs in the order from lowest to highest magnitude resulting in the flood hydrographs which are also shown on plate 33.

5-02. HYDRAULIC DESIGN

a. General. The general hydraulic design of Blue Marsh Lake Project is discussed in Blue Marsh Lake DM No. 2, Hydrology and Hydraulics. Specific hydraulic design considerations related to the Bernville Protective Works are presented below.

b. Water Surface Profiles. Backwater effects of various flood magnitudes are shown on plate 35. Backwater computations were made using HEC-2 Water Surface Profile Computer Program (September 1971, updated October 1973 version). Channel and overbank roughness coefficients were determined by field inspection and comparison with streams of similar characteristics. Discharges in the main stream above the confluence with Little Northkill Creek were reduced to account for the flows from Little Northkill Creek. Backwater computation results were used for the following:

(1) The composite SPF profile with an allowance of 3 feet for freeboard was used in determining the required top of levee design.

(2) The 100-year profile and its corresponding flow velocities were used in the design of riprap.

(3) The 50-year profile was used to check the waterway opening of the L. R. 310 bridge for compliance with the Pennsylvania Department of Transportation (PennDOT) design criteria for bridge structures.

c. Coincidental Conditions. In developing coincidental conditions (streamflow in the Northkill and Blue Marsh Lake pool levels) for the design of the Bernville Protective Works several factors were assumed. Primarily, a standard project storm (SPS) was considered to occur over the Tulpehocken Creek Watershed coincident with an initial pool elevation equal to the Spillway Crest (elevation 307.0 ft/SLD).

The portion of the basin Standard Project Flood Hydrograph contributed by the Northkill Creek was developed by applying rainfall excess increments to the unit hydrographs for the Northkill and Little Northkill Creeks. The flood hydrograph was then routed through the Blue Marsh Reservoir to determine pool elevations and flows for backwater computations. Two situations were investigated from the resulting routing. The first was a backwater effect when the maximum flow from the Northkill (19,000 cfs) was entering the reservoir. The pool elevation (315.3 ft/SLD) at the time of this maximum inflow was used as the starting water surface elevation. The second was a backwater effect when the maximum pool elevation (317.5 ft/SLD) occurred. The flow in the Northkill at the time of this maximum pool elevation was 10,000 cfs. Water Surface Profile Program HEC-2 (September'71, updated October'73 version) was used to backwater these two conditions and a composite profile based on the higher of the two water surface elevations that resulted was plotted as the levee design profile. (The two water surface profiles intersected at approximately X-Sect 5800). Manning's "n" values used in the Water Surface Profile computations were as follows:

Relocated channel 0.035; Natural channel 0.035; Overbank 0.060. Other flows were investigated to establish maximum velocities for riprap design. Flows of less than SPF magnitude floods were assumed coincidental with normal conservation pool of 285 ft/SLD.

d. Top of Protection, Freeboard Allowance, and Bridge Clearance. The top of protection for the levee was established at 3.0' freeboard (minimum) above SPF water surface elevations in the Northkill and is shown on plate 35. The lack of sufficient effective fetch length produced insignificant wave run-up based on a consideration of ETL 1110-2-8 "Computations of Freeboard Allowances For Waves in Reservoirs." Therefore, the minimum freeboard of 3 feet above the Standard Project Flood water surface elevation was adopted. This is in conformance with minimum freeboard requirements established by the Philadelphia District for similar projects.

The L. R. 310 bridge across the Northkill was investigated to determine if the existing waterway area would pass a 50-year flood (PennDOT criteria). Backwater calculations using a 50-year flow developed by the PennDOT method showed the water surface to be well below the bridge underclearance.

e. Erosion Protection. Velocities calculated for both 100-year and

Standard Project Floods were examined to determine the need for erosion protection. These calculations showed that the velocities produced by the 100-year flow (11,600 c.f.s.) on the Northkill coincident with the water surface elevation at normal conservation pool (elevation 285 ft/SLD) are the highest to be reasonably expected, and are in excess of minimum riprap velocities (i.e. critical velocities requiring riprap protection).

The bank velocities produced by the SPF conditions on the Northkill at levels above the 100-year water surface are less than minimum riprap velocities. Therefore, riprap protection to this elevation would not be required. However, flows greater than the 100-year flow could produce critical riprap velocities in the bank areas above the level of the 100-year surface profile. The water surface elevations produced by these higher flows would depend upon the assumed coincident reservoir level. Since many combinations of flow and reservoir level are possible, the upper limit (level) of riprap protection was based on an SPF flow assumed coincident with a low reservoir pool level. This results in an upper limit of riprap protection generally 5 feet above the 100-year water surface profile. Resulting riprap design velocities vary between 8 and 13 feet per second.

f. Gravity Outfall Design. A site on the left bank near the sewage treatment plant was chosen as the location for a single gravity outfall (see plate 8) through the levee. Sizing of the outfall is designed to limit the interior ponding to elevation 300 ft/SLD for a 25-year frequency peak runoff with the simultaneous operation of an 800-cfs capacity pumping station. The pumps will be activated when the water level in the ponding area reaches elevation 293 ft/SLD. Hydraulic charts presented in TM5-820-4 "Drainage for Areas Other than Airfields" were used in selecting conduit size. Inflow and outflow hydrographs showing the routing of the design flow through a reinforced concrete pipe (6-ft. diameter) and pumping stations are shown on plate 32. A cross-section profile of the outfall pipe through the levee is shown on plate 21.

Design features and criteria for the outfall are as follows:

Size of Conduit	72" dia.
Approx. Length	130 ft.
Slope of Invert	0.001692 ft/ft
Design Inflows*	1320 cfs
Conduit Inlet Invert Elevation	292 ft/SLD
Conduit Outlet Invert Elevation	291.78 ft/SLD

*Total inflow of 1,320 cfs is handled by combined capacities of gravity outfall conduit and pump station.

Alternate types of outfall conduits investigated were concrete box

culverts and round corrugated metal conduits. The concrete conduit was selected as the most economical.

g. Upper Drainage Structure Design. Two separate conduits are required to direct the flow from the upper interior tributaries (Areas 1 & 2, plate 33) under L. R. 310 and into the ponding area. The third tributary (Area 3) flows directly into the ponding area. The designed size of the conduits prevents damage to structures above the conduits, the lowest of which is elevation 302/ft SLD, by restricting the level of ponding in the area to the north of the ramp. The conduits will safely pass the runoff from a 25-year storm. Plate 20 shows the general plan and profile of the upper drainage structure. The shorter curved conduit was analyzed using two 35° mitered sections. Flows in both sections are sub-critical. The outlet invert elevation was established as 293.4 ft/SLD. This elevation was considered the lowest allowable to maintain drainage from the conduits to the ponding area and gravity outfall. Excavation of an outlet and toe drainage channel is required. The channel will extend approximately 700 feet from the combined outlet to the existing streambed in the ponding area. A typical channel cross section is presented on plate 12. Conduit size for the curved conduit was selected by the method presented in TM5-820-4 "Drainage for Areas Other than Airfields." The long conduit Section "AC" was analyzed by open channel flow since full flow would not exist at the design discharge. Corrugated metal pipe arches were selected as being the most economical conduit. Design features for the pipe arches are:

	LONG SECTION	SHORT CURVED SECTION
Length (approx)	655 Ft.	280 Ft.
Size (Span & Rise)	16'-5" x 9'-11"	11'-10" x 7'-7"
Cross Section Area	125 Sq. Ft.	70 Sq. Ft.
Design Flow	520 cfs	460 cfs
Invert Slope	0.0025 Ft/Ft	0.0047 Ft/Ft
Outlet Invert Elevation	293.4 Ft/SLD	293.4 Ft/SLD
Inlet Invert Elevation (Approx)	295.04 Ft/SLD	294.7 Ft/SLD

Design features of the outlet channel are:

Length	700 Ft (Approx)
Bottom Width	35 Ft
Side Slopes	1V on 3H
Bottom Slope	0.00135 Ft/Ft

Other conduit alternatives investigated were concrete box culverts and twin paved, corrugated metal, pipe arches.

h. Flanking Levee Drainage Conduit Design. The flanking levee (plate 11) is designed to prevent flow from an SPF flood through the saddle (minimum elev. approximately 316.5 ft/SLD at the eastern end of

Bernville. Top of levee elevation is 320.5 ft/SLD and includes 3 feet of freeboard. The flanking levee gravity outfall is a 91.5-ft.-long, 3-ft.-diameter, corrugated metal pipe. Its slope is 0.0025 ft/ft. The inlet invert elevation is 302.0 ft/SLD, the bottom of the flanking levee ponding area. The gravity outfall will keep the ponding level below elevation 312.0 ft/SLD during a 25-year rainfall occurrence. There are no structures in the flanking levee ponding area below 320.0 ft/SLD.

SECTION 6
INTERIOR DRAINAGE

6-01. GENERAL. The township of Bernville has no serious flood control problem at present, therefore, levee protection is required in lieu of land acquisition associated with construction of the Blue Marsh Lake Project.

6-02. DESIGN CRITERIA AND URBAN CLASSIFICATION. Bernville consists of relatively low-valued urban and rural residential areas and minor commercial establishments. Therefore, it was rated as Class III, according to guidelines in EM 1110-2-1410, "Interior Drainage of Leveed Urban Area: Hydrology." Listing of other design criteria used in the hydrologic and hydraulic analyses is as follows:

ETL 1110-2-8 - Computation of Freeboard Allowances for Waves in Reservoirs
EM 1110-2-1410 - Interior Drainage of Leveed Urban Areas: Hydrology
EM 1110-2-1405 - Flood Hydrograph Analyses and Computations
EM 1110-2-1601 - Hydraulic Design of Flood Control Channels
TM 5-820-4 - Drainage for Areas Other than Airfields

Appendix "M" - Report on the comprehensive Survey of the Water Resources of the Delaware River Basin, Appendix "M", Hydrology, House Document No. 522, 87th Congress, 2d Session, Vol. VI.

Weather Bureau Technical Papers Nos. 40 & 49 - Rainfall Frequency Atlas of the U. S. Handbook of Steel Drainage & Highway Construction Products-Published by American Iron and Steel Institutes, 150 E. 42nd Street New York, N. Y. 10017. Library of Congress, Catalog Card No. 78-174344.

6-03. INTERIOR DRAINAGE AREAS. Appendix III, Section III-02b of the Blue Marsh Design Memorandum No. 4, General Design Memorandum, covers the interior drainage and lists the pertinent data associated with the interior drainage areas. A more general description of the drainage areas located in the Tulpehocken Creek Watershed and applicable tables are given in section 2 of the Blue Marsh Design Memorandum No. 2, Hydrology & Hydraulics. The combined drainage area tributary to the gravity outfall and pump station is 2.57 square miles.

6-04. PONDING AREA. The ponding area behind the levee is located in the vicinity of the Bernville Sewage Treatment Plant, on the left bank at the downstream end of the relocated channel. It covers approximately 13.7 acres. The area-capacity curve is on plate 32. The ponding area will be landfilled to 292.0 ft/SLD and graded toward the gravity outfall. This will allow the excess runoff to drain into the Northkill when the stage on the Northkill is below elevation 291.8 ft/SLD. The ponding area will also be drained by four 200-cfs-capacity pumps. There are no

secondary ponding areas. All interior runoff drains into the main ponding area.

6-05. PONDING STAGES. Ponding Stages were selected according to criteria on Page 10 of EM 1110-2-1410.

Ponding Stage	Elevation (ft/SLD)
A	300
B	302
C	304
D	310

The ponding stage selected for design was ponding Stage A; elevation 300 ft/SLD. A lower limit on ponding, elev. 300, was selected rather than elev. 301 as presented in the General Design Memorandum, based on more detailed survey information together with resulting refinement of hydrological data. This elevation was selected to prevent damage to structures and avoid acquisition of additional expensive real estate.

6-06. PUMP STATION CAPACITY. The pump station consists of four 200-cfs (90,000 GPM) capacity pumps. It is designed to keep the water surface in the ponding area below 300 ft/SLD during a 10-year storm with the gravity outlet closed. When used with the gravity outfall it protects against a 25-year storm. Computer Program 22-J2-M108 (Program for Reservoir Routings) was used in sizing the pump capacities. This program routes various frequency storm hydrographs through a reservoir and computes ponding area content and water surface elevation for various discharges.

6-07. EXISTING SEWERS.

a. Storm. There is no major storm sewer system in the Borough Bernville and most of the runoff is carried directly by the street gutters into Northkill Creek or its tributaries. A small portion of the total runoff is collected by catch basins that contribute the flow to individual storm sewer lines. Two of these lines, located on the left and right side of Fourth Street, respectively, flow into Northkill Creek and they may be affected by the proposed relocation of L. R. 310. Since there are no plans available of the existing storm sewer lines, field surveys are required to determine the need for redesign of the two lines. This will be accomplished before completion of the contract plans. No other storm sewer lines will be affected by the construction of the proposed protective works.

b. Sanitary. The Borough of Bernville has a municipal sewer system and treatment plant, which is located between L. R. 310 (Pa. Rt. 183) and the Northkill Creek in the southwest part of the borough. The existing 10" outfall line, which flows from the plant into the Northkill Creek, will be eliminated because of the proposed levee alignment. Under the

levee, the line will be removed and all open ends plugged. A new 12" cast iron pipe will carry the effluent from an existing manhole in the plant to the sanitary effluent outfall (Drainage Structure No. 3) at the pumping station. During high stages on Northkill Creek, the effluent will be collected in a sump and pumped out. For the profile of the proposed sewer line to the sanitary effluent outfall, see plate 22. In the borough, an 8" sewer crosses L. R. 310 and runs parallel to it on the right side; this line will be affected by the relocation of L. R. 310. The line has sufficient cover, but the manholes along L. R. 310 will be raised to meet the new grade or embankment of the highway. Relocation of any additional existing sewer lines is not anticipated.

c. Combined. There are no combined sewers that carry both storm flow and sanitary flow in the Borough of Bernville.

6-08. DRAINAGE STRUCTURES.

a. Drainage Structure No. 1. (Shown on plate 21) This structure is a gravity outlet that will pick up normal stream flow and storm runoff in the ponding area and carry it through the levee into Northkill Creek. The conduit will be a 72" circular, reinforced concrete pipe approximately 130 ft. long. Each end will have a reinforced concrete endwall and wingwalls. On the downstream end of the pipe, a flap gate will prevent flooding behind the levee during high stages on Northkill Creek. A reinforced concrete gate well with a sluice gate will be located near the centerline of the levee; this will provide a positive cutoff against backwater if debris should keep the flap gate open. The pipe will also have an 11' x 11' x 1' concrete seepage diaphragm to prevent undercutting by seepage flow.

b. Drainage Structure No. 2. (Shown on plate 22) This structure is a gravity outlet that will carry the storm runoff through the flanking levee. The conduit will be a 36" circular, corrugated metal pipe approximately 90 ft. long. The pipe will be bituminous coated inside and outside and the invert paved. This pipe will have a reinforced concrete end wall and wingwalls on each end. A flap gate will also be provided on the downstream end of this pipe to prevent flooding behind the levee from high creek stages. A precast concrete gate well with sluice gate will provide a positive cutoff against backwater. This drainage structure will have a 7' x 7' metal seepage diaphragm to prevent undercutting by seepage flow.

c. Drainage Structure No. 3. (Shown on plate 22) This structure is a gravity outfall line that will carry the sewage effluent of the Bernville Treatment Plant from the pumping station into Northkill Creek. The pipe will be 12" cast iron, approximately 245 ft. long. On the outlet end, there will be a concrete endwall and flap gate to prevent backflow. During high stages on Northkill Creek, the effluent will be collected in a sump and pumped out through the levee. Like the other

drainage structures, a precast concrete gate well with a sluice gate will provide positive closure. A 5' x 5' x 1' concrete seepage diaphragm will prevent undercutting by seepage flow.

d. Upper Drainage Structure. (Shown on plate 20) This structure will carry the storm runoff from the upper interior tributaries (Areas 1 and 2, plate 33) under L. R. 310 and into the ponding area. The structure will have two, corrugated metal pipe arch conduits consisting of a 16'-5" x 9'-11" arch, approximately 655 feet long, and a 11'-10" x 7'-7" arch, approximately 280 feet long. The pipe arches will be bituminous coated inside and outside and the inverts will be paved. Reinforced concrete endwalls and wingwalls will be provided at the entrances and common outlet.

e. Miscellaneous Culverts. Existing culverts under L. R. 310 carry storm runoff from the Borough of Bernville and surrounding farm areas into the Northkill Creek. The cluverts are circular, reinforced, concrete pipes ranging from 15" to 24" in diameter, except for two box culverts that measure 6' x 4' and 12' x 8', respectively. The relocation of Northkill Creek and construction of the proposed levee necessitate changes in the flow patterns and existing culverts. The flows will be rerouted into the ponding area between the levee and L. R. 310 for discharge into the Northkill Creek through Drainage Structure No. 1 or the pumping station.

From L. R. 310 Station 736+00 to Station 746+50, where the levee and highway are combined, all existing culverts will be removed. Flow to the existing 12' x 8' box culvert at Station 742+62 and flows to the existing culvert at Station 736+60 will be diverted by channel relocation into a new 16'-5" x 9'-11" corrugated metal pipe arch culvert at Station 732+86. New culverts will be installed under relocated L. R. 06017 to carry the storm runoff from the Penn Township School. At Station 732+50, the existing culvert will be replaced by a new 11'-10" x 7'-7" corrugated metal pipe arch culvert and the flow will be diverted to the ponding area.

SECTION 7
PUMPING STATION

7-01. GENERAL. A pumping station will be provided on the landside of the levee at approximate levee station 55+40. Below the motor floor (elevation 303.0), the substructure will be approximately 91 feet long and 42 feet wide and will be constructed of reinforced concrete. It will be divided into four main chambers, one for each of the 90,000-gallons-per-minute pumps, and a chamber for the sewage pumps which will discharge effluent from the Bernville treatment plant during high stages on the Northkill Creek. The sewage pump chamber will also serve as a low level sump to drain water from the intake area when the depth is not sufficient to operate the main pumps. Sluice gates will be provided to close off individual chambers. Access hatches to each chamber will be provided in the motor floor. Trash racks will be provided to protect the pumps. The racks will be constructed of structural steel, coal-tar enamel or epoxy coated, and will be arranged to permit raking from the walkway. Fastenings will be of corrosion-resistant steel. The walkway will be accessible from the interior of the building and will be inclosed by a safety handrail. A plan and sections through the substructure are shown on plate 23. Above elevation 303.0, the building will be approximately 91 feet long and 28 feet wide and will provide inclosed space for pump motors, switch gear, dehumidfier, and operating equipment. The roof system will consist of 5-ply, built-up roofing over rigid type insulation secured to a ribbed steel deck. The steel roof deck will be supported by open-web steel joists and steel beams bearing on masonry walls. Roof openings, covered by removable hatchcovers, will be provided for installation and removal of pump units. Exterior walls will be constructed of brick-faced, hollow concrete masonry units. Control joints and horizontal joint reinforcing will be provided for crack control. Solid masonry load-bearing pilasters or columns will be provided at bearing points of heavy concentrated loads. Industrial type, vapor tight, metal access doors will be provided at convenient locations. The building will be windowless for better security and to discourage vandalism.

7-02. STRUCTURAL.

a. Design Criteria.

(1) General. Working stresses, design criteria, loading conditions, and design assumptions and methods are based on applicable Corps of Engineers' engineering and design manuals or with industry codes, supplemented where necessary, by conservative judgment and experience. Publications used in establishing design criteria include the following:

Manuals - Corps of Engineers

EM 1110-2-2000, 1 November 1971, Standard Practice for Concrete.
EM 1110-1-2101, 1 November 1963, Working Stresses for Structural Design.

EM 1110-2-2103, 21 May 1971, Details of Reinforcement - Hydraulic Structures.
EM 1110-2-2502, 29 May 1961, Retaining Walls.
EM 1110-2-3104, 9 June 1958, Structural Design of Pumping Stations.

Engineering Technical Letters - Corps of Engineers

ETL 1110-2-184, 25 June 1969, Gravity Dam Design.

Other Publications

ACl Building Code (ACI 318-71)
AISC Manual of Steel Construction, 1970.

(2) Concrete. The reinforced concrete will be designed with working stresses given in the ACl Building Code, and based on an ultimate compressive strength (f'c) of 3,000 psi at 28 days. Working stress modifications for hydraulic structures will be in accordance with EM 1110-1-2101.

(3) Concrete working stresses. The following tabulation lists the reinforced concrete working stresses to be used in design:

Compressive stress (f'c)	
28 Day Strength	3,000 (psi)
Flexure (f'c)	
Extreme fibre stress in compression, 0.35 f'c	1,050
Shear (v)	
As a measure of diagonal tension at distance "d" from the face of the support.	
Beams with no web reinforcement, $1.1\sqrt{f'c}$	60
Members with vertical or inclined web reinforcement or properly combined bent bars and vertical stirrups, $5\sqrt{f'c}$	274
Development length (l_d)	
The basic development length shall be	$0.04\ A_b f_y / \sqrt{f'c}$
but not less than,	$0.0004\ d_b f_y$

(4) Reinforcing Steel. All reinforcing steel bars will be designed for the working stresses of new billet steel, intermediate grade, deformed bars with a minimum yield point of 40,000 psi. Working stresses will be in accordance with the requirements of the ACI Building Code, except as modified in EM 1110-1-2101. The working stress in flexural tension was established at 20,000 psi.

Minimum embedment lengths and splice lengths shall conform to ACl 318-71 and EM 1110-2-2103. Splices at points of maximum moments will be avoided

and,where possible, will be staggered in adjacent bars. When the structural analysis indicates that bending and direct stress exists under the critical loading, reinforcing steel, if required, will be computed for both bending moment and axial load.

Temperature and shrinkage reinforcement will be provided in accordance with the applicable requirements of ACI 318-71 and EM 1110-2-2103.

(5) Structural steel. Structural steel will be designed for the working stresses of ASTM A36 steel and in accordance with the AISC Specifications except as modified for hydraulic structures by EM 1110-1-2101. Conforming to the requirements of EM 1110-1-2101, the working stress in tension for A36 steel will be 0.50 FY or 18,000 psi.

b. Basic data and assumptions.

(1) Dead loads. The following unit weights in pounds per cubic foot will be used:

Random Backfill, drained	125
Random Backfill, submerged	72.5
Concrete, plain and reinforced	150
Structural steel	490

(2) Live loads. The following live loads will be used:

Water	62.5 lbs. per cu. ft.
Equipment	As applicable
Floor slabs & beams	100 lbs. per sq. ft. plus heaviest equipment load, when applicable
Roof (minimum)	25 lbs. per sq. ft.
Pump thrust	As applicable

(3) Water pressures. Hydrostatic pressure as submerged fill and free water will be applied to the structure by conventional pressure distribution. Uplift pressures are treated as shown under loading conditions.

(4) Earth pressures. In general, earth pressures will be determined in accordance with EM 1110-2-2502, 29 May 1961, Retaining Walls.

c. Loading conditions. The stability of the structure has been analyzed for the following loading conditions:

Case I. Construction condition.

Substructure w/o equipment.
Dead load of structure.

Lateral earth load.
Lateral load due to compacting equipment.

Case II. Floatation condition.

Dead load of structure.
Pond at Elevation 300.
Gates closed and no water in sumps.
100 percent uplift over 100 percent base.
Lateral earth load.

Case III. Operating condition.

Dead load of structure.
All pumps operating.
Pond at Elevation 300.
100 percent uplift over 100 percent base.
Lateral earth load.

Stability requirements are as follows:

Resultant shall be within base.

Shear-friction factor of safety shall not be less than 1.5 for plane between concrete and rock and 4 for plane through rock.

Maximum foundation pressure not to exceed 10 tons per square foot. The structure will be stable under all conditions of loading. Stability computations are presented in appendix C.

d. Design and analysis.

(1) Substructure. The walls will be designed to withstand the hydrostatic and lateral earth loads. The deck slab will be designed for live load and equipment load. The base slab will be designed to withstand the foundation pressure. Design will be based on the working stress design method and shall conform to the requirements of EM 1110-2-3104. Minimum reinforcing steel will be that required for temperature and shrinkage in accordance with EM 1110-2-2103.

(2) Roof. The roof be designed for dead load, live load, and wind load in such combi. as will produce the greater stress in the member under consideration. Live load will be the greater of a 25-pounds-per-square-foot snow load; or the load produced by ponded water to the maximum depth permitted by the overflow scuppers in the event that roof drains become clogged. Wind load will be considered as an outward pressure, normal to the surface, of 25 pounds per square foot, in accordance with EM 1110-2-3104.

(3) Walls. The walls will be designed for dead load, superimposed loads, and lateral wind force. Wind force on exterior walls will be

considered as a horizontal pressure of 20 pounds per square foot; acting either inward or outward, in accordance with EM 1110-2-3104.

7-03. MECHANICAL.

a. General. This subsection presents the pertinent information concerning the mechanical design of the Bernville Pumping Station including pumps, drives, gates, and operating accessories.

b. Design Criteria. The pump station will be designed in accordance with EM 1110-2-3105, Mechanical and Electrical Design of Pumping Stations, and the current edition of the Hydraulic Institute Standards. The inflow into the ponding area, as set forth in Section 4, Hydraulic Design, requires a pumping capability of 360,000 gpm at ponding elevation 293 feet MSL with reservoir elevations up to 317.5 feet MSL. Four equal capacity pumps have been selected to provide this flow. The storm water pumps will be designed to operate between ponding elevation 292 feet MSL and 300 feet MSL. The total dynamic head (TDH) for the pumps was determined by taking the static head from the ponding elevation on the protected side of the levee to the top of the levee plus the full diameter of the pipe and adding the losses. The components of the total dynamic head are as follows:

TABLE 3
HEAD LOSSES

Conditions	Static	Exit	Pipe	Pump	TDH
1. Pond El 293.5 (Starting Head)	33.5	.65	1.78	1.3	37.23
2. Pond El 293.5 w/Reservoir El 290	2.5	1.06	2.28	2.0	7.84
3. Pond El 293.5 w/Reservoir El 317.5	24.0	0.78	1.96	1.3	28.04
4. Pond El 300.0 w/Reservoir El 290	-4	1.16	3.7	2.5	3.36
5. Pond El 300.0 w/Reservoir El 317.5	17.5	0.87	2.1	2.5	23.0

The storm water pumps will be designed to pump a minimum of 90,000 gpm at all of the above conditions.

c. Station Arrangement. The pump station was designed for four main storm water pumps, one storm water pump in each sump, and one combined sewage and seepage sump with duplex non-clog sewage pumps. During

low stages on Northkill Creek the interior drainage flows collected by the creeks in the area and the sewage treatment plant effluent will flow by gravity to the reservoir side of the levee and into Northkill Creek. The gravity outlets will be equipped with flap gates to prevent back flow during periods when the reservoir is at a higher elevation than the outlet pipe inverts. During these periods, all water will be pumped across the levee. Sluice gates have been incorporated into the gravity outlets to provide a positive shut-off in case of flap gate failure. Sluice gates will be provided to close off the sewage and seepage sump and the main sumps. The main sump inverts are located essentially at elevation 279. The main sumps are sloped to drain toward a gutter which is sloped to drain toward the sewage and seepage sump. The sewage and seepage pumps will serve to unwater all the sump areas to a minimum elevation of 278.

d. Storm Water Pumps. The storm water pumps were selected in accordance with EM 1110-2-3105, Calculations, upon which the pump selection was based, are shown in appendix C. The calculations show that a mixed flow pump will most efficiently produce the maximum head required. However, due to the rapid increase in flow as the pumping head decreases, the mixed flow pump is not practical and will not perform properly through the full range of pump heads. The pumps will operate under low heads most of the time but must be capable of pumping 9000 gpm at the high head. A two-stage axial flow pump with its steeper flow curve will be able to operate over a wider pumping head range without causing damage to the pumps.

The stormwater pumps will start at elevation 293.5, and pump down to elevation 292. The pumps will have automatic start and stop. The automatic operation is required since the ponding area is very small and the time required to fill the pond to elevation 293 is less than one hour. The ponding area maximum water, elevation 300 feet MSL, is critical in that above that elevation damage will occur within the protected area. The minimum time required for the pond to reach elevation 300 for design conditions is 5 hours. This amount of time is not considered sufficient in all cases to allow the operator to get to the pump station, raise the main gates and start the pumps. The pumps will be controlled by float switches which will start the pumps at three-inch intervals after elevation 293.5. All pumps will be operating above elevation 294.25 feet. A lock-out will be incorporated into the control system to prevent a second pump from starting before the previous pump is up to full speed. A time delay will be used to prevent the pumps from being restarted while they are turning in reverse due to the reverse flow of the water in the discharge pipe. The lead pump will be alternated automatically after each start.

The storm water pumps will be driven by 1000-horsepower, vertical, electric motors. In order to keep the building superstructure to a minimum height, each pump and motor will be removed by a mobile crane

through a roof hatch located over each pump. Any routine maintenance requiring the use of chain hoists will be accomplished in coordination with a portable gantry crane.

The pump dimensions shown on plate 23 have been taken from EM 1110-2-3105, and are in basic agreement with current pump manufacturers data. During the contract plans and specifications s'age, the use of a suction umbrella to lower the pump approach velocities will be investigated with the pump suppliers.

Each pump will have an automatic (farval type) grease lubrication system to assure adequate lubrication of the propeller and main shaft bearings, and allow the pumps to be excercised without water in the sump. The storm pumps will discharge through individual, 6-foot diameter over-the-levee discharge pipes which will terminate in the outlet structure with a flapgate. The pipe material as originally designed was steel but due to the steel shortages, reinforced concrete, cylinder pipe will be used. The pipes over the levee will be mounded over by fill. The high point of the discharge pipe inverts will be elevations 321 feet MSL.

e. Sewage and Seepage Pumps. The sewage and seepage pumps will be sized to pump the maximum design flows over the levee during high reservoir elevations. The pumps will be of the non-clog type, suitable for use in a wet sump. The pumps will discharge through a common 8-inch-diameter, over-the-levee, force main with high point invert of 321 feet MSL. The line will be maintained under a minimum cover of 3 feet and will remain full of liquid in order to prevent reverse turbing and short cycling the pumps. Provisions will be made for draining the line during the winter, however, no problems with freezing in the sump are anticipated due to the sump design. The sewage pumps will be equipped with an automatic grease lubrication system. The pumps will be float controlled and have an alternator system to change the lead pump after each start.

f. Ventilation System. Due to the absence of windows in the pump station, a system of air inlet openings and exhaust fans will be provided for ventilation and heat removal for human comfort. The air inlet louvers will be of the combination type with weatherproof fixed louvers on the outside and manually adjustable louvers on the inside. Bird screens will be provided over all openings. The roof ventilators will have manually openable shutters to provide natural as well as power ventilation. The roof ventilators will have a combined capacity of 14,000 cfm which will provide the pump station with one air change every three minutes.

g. Dehumidification. Two dehumidifiers will be provided to control the humidity in the pump station. They will be located at opposite ends of the station to limit the amount of ductwork required to distribute the air. The station floor will have a vapor barrier and all openings to the room will be of the vapor-tight type.

h. Heating. No heating is anticipated for the pump station interior. The dehumidification system will provide a limited amount of heat and all equipment inclosures will contain equipment heaters.

i. Corrosion Mitigation. The water in the Northkill Creek has been monitored for a period of 2 years. The water shows no unusual problems and has consistently maintained an average pH value of between 7 and 7.5. Therefore, no corrosion protection for the equipment in the Bernville Pumping Station is anticipated.

7-04. ELECTRICAL.

a. General This subsection presents the pertinent information concerning the electrical design of the Bernville Pumping Station including Power Supply, Pump Motors, Switch Gear, and Station Grounding System.

b. Design Criteria. The pump station electrical system will be designed in accordance with EM 1110-2-3102, General Principles of Pumping Station Design & Layout, EM 1110-2-3105, Mechanical & Electrical Design of Pumping Stations, National Fire Protection Association Publication No. 70 (latest edition) National Electrical Code, IEEE Standard 142, Recommended Practice for Grounding of Industrial and Commercial Power & Systems & The National Electrical Safety Code.

c. Power Supply.

(1) General. Power will be supplied by the Metropolitan Edison Co. which is a member of the "PJM" interconnection. Copies of correspondence with Metropolitan Edison Company are included in appendix D for reference.

(2) Supply Source Voltage. The Pumping Station will be served by constructing a 69KV tap line approximately 1 mile long from Metropolitan Edison Company's existing 69KV transmission line which passes north of Bernville. See plate 25 for location of power source.

(3) Alternatives. Single Circuit 13.2 KV, Double Circuit 13.2 KV, Single Circuit 69KV with Single Circuit 13.2 KV backup and double circuit 69KV services were considered as alternatives to the single circuit 69KV service proposed. Our studies of the various alternatives are still continuing particularly with regard to the power company's ability to start the main pumps on its existing 13.2 KV line. Starting considerations might preclude the 13.2 KV alternatives. The project's relatively small ponding area requires that the pump station be capable of fully automatic operation. To realize an increase in reliability through the installation of dual service facilities, they would have to be capable of automatically isolating any faulted substation components

and automatically switching to the alternate line or component. Basically this would require three extra primary breakers, one extra main transformer, and one extra secondary breaker plus all required appurtenances and control equipment. This, of course, would have a significant effect on the cost of the service. The following tabulation presents the effect on the overall cost of the plant electrical system and service of the several alternatives considered. Only that portion of each cost factor affected by the type of service has been included, those items not affected, such as the main pump motors etc., are not included. A sum of $50,000 has been included in all the 69KV alternatives to provide autom   c sectionalizing of the portion of the power company's line serving the plant. This is further discussed in paragraph 7-04 C (4) "~~Service~~ Arrangement" below.

TABLE 4
Cost Comparison-Service Alternatives

Service Type	Cost Factors	Amount
Single Circuit 69KV (recommended system)	Line extension	$110,000
	Sectionalizing	50,000
	Substation	74,000
	Across the line starters	31,000
	TOTAL	$265,000
Single Circuit 13.2 KV	Line extension	$ 23,000
	Substation	58,000
	Reduced voltage starters	64,000
	TOTAL	$145,000
Double Circuit 13.2 KV	Line extension	$223,000
	Substation	172,000
	Reduced voltage starters	64,000
	TOTAL	$459,000
69KV Main Supply with 13.2 KV backup	Line extension	$133,000
	Substation	170,000
	Reduced voltage starters	64,000
	TOTAL	$367,000
Double Circuit 69KV on same poles	Line extension	$300,000
	Sectionalizing	50,000
	Substation	214,000
	Across the line starters	31,000
	TOTAL	$595,000

TABLE 4 (Cont.)

Service Type	Cost Factors	Amount
Double Circuit 69KV on separate pole lines	Line extension	$350,000
	Sectionalizing	50,000
	Substation	214,000
	Across the line starters	31,000
	TOTAL	$645,000

The several alternatives are further discussed below:

(a) Single Circuit 69KV (Recommended System). We feel that this system provides the best overall compromise between cost, reliability and system complexity. The line will be on a cross-country right of way along essentially high ground. This reduces the danger of damage from vehicular accidents and flooding. Only one set of incoming line breakers, transformers and appurtenances will be required. Reduced voltage starters will not be required.

(b) Single Circuit 13.2 KV. An extension of the existing 13.2 KV line feeding Bernville would provide the lowest cost service facilities. We do not recommend this because Utility Co. voltage drop restrictions would require installation of reduced voltage starters, which would increase system cost and complexity. This line is located along a highway and passes through low areas subject to flooding. It is, therefore, susceptible to both vehicular and storm damage. We feel a back-up source would be needed to assure a reliable service if this line were the primary source of power to the pump station.

(c) Double Circuit 13.2 K is arrangement would consist of the above Single Circuit 13.2 KV lin plus a back-up source fed from the Bern Church Substation. This is not recommended because its total cost exceeds that of the proposed single circuit 69KV service, and the switching system for a double circuit 13.2 KV service is far more complex. The voltage drop on the back-up service would exceed the amount normally permitted by the utility company.

(d) Single Circuit 69KV with 13.2 KV Back-up. This would consist of the recommended 69KV service plus the single 13.2 KV service discussed in (a) above used as a back-up. It is not recommended because its total cost exceeds that of the recommended service and would involve a more complex switching scheme.

(e) Double Circuit 69KV. Either of the double circuit 69KV services would provide somewhat greater reliability but at a large increase in cost and would involve a much more complex switching scheme. The double circuit line would simply add a second circuit via this same right of way, possibly on the same structures. Both have the same power source.

For the above reasons,double circuit 69KV service is not recommended.

(4) Service Arrangement. The station will be served by a single incoming line. Metropolitan Edison Company can include automatic sectionalizing equipment on its lines to preclude outages of the type which occurred on 24 November 1972. (See its letter dated 18 November 1974 in appendix D.) The sectionalizing equipment would have the effect of placing our 69KV tap point at the junction between two sections of its 69KV line rather than at the midpoint of a single section. An outage to a single section could not, therefore, interrupt our service. Because of the 69KV lines'large degree of inherent reliability and because a truly independent second source of 69KV power is nonexistent and because only limited space is available in the pumping plant substation area, no provisions have been made for dual service. See plate 26 Pump Station Electrical one line Diagram.

(5) Station Service Power Supply. The limited size of the ponding area has necessitated an automatic starting system for the storm water pumps. The 69KV Service will,therefore,be constantly energized and station service power can be taken from this same source through a step-down transformer. This arrangement will save the extra cost of installing a second overhead service line to provide Station Service Power.

d. Motors.

(1) Type. Motors will be 1,000-hp, 2,300-volt, 3-phase, 60-hertz, self-excited synchronous type.

(2) Control. The motors will be arranged for automatic start and stop. As previously stated,automatic control is needed because of the small ponding area. Control circuits will be arranged to provide protection against simultaneous starting of all units following a power interruption. This station will not be operated by a local agency and, therefore,adequate maintenance for the automatic controls will be available through the efforts of our own personnel and/or contractor maintenance.

An air circuit breaker will feed a motor control center containing one 2,400-volt, fused, snychronous motor starter arranged for across the line starting for each 1,000-hp pump motor. The fused motor starters have been selected instead of oil,circuit-breaker type equipment because they are cheaper and are considered very reliable for use in motor-starting applications.

e. Transformers.

(1) Main Power Transformer. This transformer shall be rated 69KV to 2.4 KV with sufficient capacity to carry the entire pump station load. A three-phase unit was chosen because of space limitations. The transformer will feed a metal-clad switch gear unit located inside the plant.

(2) Station Service Transformer. This transformer shall be rated 2,400-208/120-volt, indoor, dry type. It will be fed from an air circuit breaker in the metal-clad switch gear which is supplied by the main power transformer.

f. Switch Gear. Equipment shall consist of 2.4KV metal-clad switch gear with one main and two branch circuit air circuit breakers. One branch feeds the motor control center containing the high voltage starters supplying the main pumps. The other branch feeds the station service transformer and its related loads.

g. Station Service System. The station service system shall feed a 208/120-volt panel which will serve receptacles, lighting, dehumidification, control, sump pumps, seepage and sewage pumps, portable gate operator and equipment heaters. Station Service Wiring shall consist of wire insulated per Guide Specification CE 1404-04 installed in rigid galvanized conduit.

(1) Interior Lighting. The interior of the pump station will be lighted to 30-foot candles using standard, dome type, incandescent fixtures. Mercury vapor fixtures could also be used but the infrequent operation of the lights would not justify their installation.

(2) Exterior Lighting. Mercury vapor fixtures with 250 watts will be installed on the exterior building walls to provide security lighting. Outlets will be provided above the trash racks for portable floodlights to facilitate night time emergency raking.

h. Grounding System. The fence around the substation shall be grounded in accordance with TM 5-765. The pump station and substation grounding system shall be designed in accordance with IEEE Standard 142-1972 and shall have a resistance of 3 ohms or less. Grounding systems shall consist of interconnected driven ground rods. The quantity of rods needed will depend on the soil resistivity found at the site.

i. Communications. Empty conduits will be provided for installation of telephone system wires and telephone or other lines needed in conjunction with the instrumentation and alarm equipment described below. One standard telephone instrument will also be installed inside the pump station.

j. Instrumentation and Alarm Systems. The dam tender and his assistant will be the only persons available to check the proper operation of the pump station during flood emergencies and attempt to correct any malfunctions. We must, therefore, provide the following instrumentation and alarm readouts to keep them apprised of plant conditions:

(1) A ponding level stage recorder which can be interrogated by phone from the operations building or elsewhere.

(2) An alarm system that will automatically ring the phones at the dam area when the ponding level at the intake reaches elevation 290. This will enable the dam tender to call the power company to insure that our service is energized and alert them that the pumps are likely to start.

(3) A display at the operations building indicating pump operation.

7-05. ARCHITECTURAL. The architectural treatment of the pumping station, as shown on plate 27, emphasizes its verticality and height as it looms out of the ponding area. This is made more pronounced by the vertical construction joints in the brick walls and by the vertical concrete fins between the trash racks. The fins throw strong shadows on the trash rack and dramatize both the slanting character of the racks, and the height of the building.

Another important influence on the design, as pointed out in EM 1110-2-3103, is the fact that pumping stations are left unattended most of the time. Consequently, this building will be without windows and will be faced with brick because of that material's durability.

A third influence on the design was the need to make the building compatible with the neighboring sewage treatment plant, with its salmon-colored brick and precast concrete trim. The use of precast concrete facias and buff brick in the pumping station should accomplish this aim and together with the dark color of the racks and railings will provide a good color combination.

Planting is planned close to the security fence of the adjacent electric substation in order to partially shield it from the view of the town. It is also recommended that trees and other appropriate plantings be utilized throughout the general surrounding area in order that it may, as much as possible, be returned to its former greenness and beauty.

7-06. MISCELLANEOUS FEATURES.

a. Discharge Lines. Four prestressed concrete cylinder pipes will carry discharges from the main pumps over the levee to a reinforced concrete outlet structure. The use of metal pipe, as generally recommended by EM 1110-2-3102 for this type of application, was rejected due to recent difficulties experienced in obtaining large diameter steel pipe for the outlet works of the Blue Marsh Lake project. Bolt-harnessed flexible joints will be used to transfer thrusts through the steel cylinder cores of adjacent sections. Discharge from the sewage pumps will be carried by a single cast-iron pipe over the levee to the outlet structure. Flexible couplings will be provided on all discharge pipes at structures and bends. Typical sections through the discharge lines are shown on plate 24.

b. Vehicle Access. A 12-foot-wide, bituminous paved, service road will be provided from the existing sewage treatment plant access road to the pumping station. A bituminous paved turnaround and limited parking space will be provided adjacent to the building.

c. Substation. A fenced enclosure will be provided adjacent to the building for the transformers serving the pumping station. The fence will be a chain link security type, 8 feet in height. The enclosure will be accessible from the interior of the building and a vehicle access gate will be provided in the fence.

d. Flood Wall. A T-type reinforced concrete wall will extend about 25 feet from the south end of the pumping station to retain the fill in the substation area. This wall will connect with a flood wall which will be provided to protect the low side of the sewage treatment plant area. The flood wall will be a cantilever T-type with the top at elevation 303.0 and a total length of approximately 300 feet.

e. Approach. A channel will be provided, as shown on plate 8 to direct the flow to the intake area. The channel will have a curved alignment and will be approximately 112 feet long. Maximum slope will be 1V on 6H in the direction of flow from a control sill at elevation 293.0 to the invert of the intake at elevation 279.0. Side slopes will be excavated to 1V on 3H. Bottom and sides of the channel will have riprap protection. The control sill will be constructed of reinforced concrete and will have an entrance width of 50 feet. Details of the control sill are shown on plate 24.

SECTION 8
RELOCATIONS

8-01 GENERAL. Construction of the protective works for the Borough of Bernville will affect the facilities of three legislative routes, three borough streets, a power company, a telephone company and the borough sewer system. Summary of costs, and detailed estimate are shown on table 4.

IDENTIFICATION OF OWNERS

Pennsylvania Department of Transportation
District 5-0
1713-1741 Lehigh Street
Allentown, PA 18105
Mr. A. Victor Cesare
District Engineer

Borough of Bernville
316 Main Street
Bernville, PA 19506
Mr. Stanton H. Clay, Mayor

Metropolitan Edison Company
P. O. Box 542
Reading, PA 19605
Mr. Robert Zechman, Supervisor Division Engineering

Bethel and Mt. Aetna Telephone and Telegraph Company
60 E. Washington Avenue
Meyerstown, PA 19602
Mr. James Vallosio, Supervisor Engineering Department

Heidelberg, Incorporated
Bernville, PA 19506
Mr. John Guenther, President

Penn Township
Route #2, Bernville, Pa.
Mr. Norman Ernst, Secretary

8-02 LEGISLATIVE ROUTES.

a. Miscellaneous Criteria.

(1) Classification of Highways. The Pennsylvania Department of Transportation (PennDOT) has classified the highways in the Commonwealth according to anticipated traffic a roadway will carry. The classification used for design of the highway relocations has been determined

using average daily traffic counts for the time of taking in accordance with PennDOT criteria.

(2) Pavement Design. The pavement and subbase depths will be based on pavement design analysis in accordance with PennDOT Design Manual, Part 2.

b. LR 310 (PA 183). This Class 2 highway is the principal north-south highway in the vicinity of the project. The road borders about 4 miles of the northern side of the reservoir area between Pleasant Valley, about 2 miles upstream of the dam, and Bernville.

(1) Necessity for Relocation. West of Bernville, the levee paralleling the Northkill Creek on the left bank overlies the existing LR 310 necessitating relocation. The only feasible relocation is on top the levee along approximately the existing horizontal alignment. Relocation to the west would be in the reservoir and to the east through the built up section of Bernville.

(2) Requirements. Based on a Design Hour Volume of 605 at the time of taking, the PennDOT classification standards specify a Class 2 highway for LR 310.

(3) Proposed Relocation. Relocation of LR 310 at Bernville, presented on plates 5 through 7, consists of raising about 3,500 feet of roadway on approximately the existing horizontal alignment. The new highway will have a pavement width of 24 feet and 10-foot paved shoulders to meet the criteria for Class 2 highways. The maximum grade of 2.1 percent to reach the top of dike is below the allowable 4 percent.

(4) Maintenance of Traffic. Traffic will be routed through the Borough of Bernville along Third and Main Streets. A plan of the detour system will be incorporated in the final construction plans in accordance with PennDOT regulations.

c. LR 06017 will be ramped up on the existing alignment to intersect the raised LR 310. The 500-foot ramp will have a pavement width of 22 feet to match the existing roadway and 10-foot shoulders. T-715 will be raised on its existing alignment to intersect the raised LR 06017. There is sufficient area on the east side of the existing LR 06017 for a temporary road for maintenance of traffic.

d. LR 06047 crosses the Northkill Creek and the proposed levee just upstream of the planned pumping station. This highway is to be relocated as indicated in Design Memorandum No. 11, Highway Relocations, previously submitted. Design and cost estimates for this road relocation are covered in Design Memorandum No. 11.

e. Views of Owner. Highway representatives have indicated general approval of the plans and expressed satisfaction with alignment and grade. Final line and grade approval will be obtained in the final design stage.

f. Proposed Relocation Contract. A relocation contract without betterments will be negotiated with the Commonwealth of Pennsylvania wherein the Government will provide for the relocation of the roads. Final plans and specifications will be prepared by Government, and the construction work will be advertised and accomplished by means of a construction contract, under the supervision of the Government. The Government will acquire the necessary rights-of-way.

8-03 BERNVILLE BOROUGH STREETS

a. Miscellaneous Criteria. The Borough of Bernville does not have a published standard for street design. Design, therefore, of the access ramps to LR 310 will be in accordance with paragraph 73-209.2 (e) (4) or ER 1180-1-1 and to match existing streets.

b. Four borough streets, Washington, Fourth, and Third Streets and Fisherman's Lane will be ramped up to meet the raised LR 310. In addition, two alleys between Third and Fourth Streets will be ramped up to LR 310, and Fox Alley will be ramped to meet Washington Street.

c. Necessity for Relocation. Ramping of these streets and alleys up to the raised LR 310 is required to maintain traffic patterns and retain existing level of service of the borough.

d. Views of Owners. Borough representatives have indicated general approval of the plans and expressed satisfaction with alignment and grade.

e. Proposed Contract. Road and street relocations required by the Bernville protective works will be included in the lump sum construction contract for the levee.

8-04 SEWER LINES. The effluent outfall from the Bernville sewage treatment plant to the Northkill Creek will be rerouted as shown on plate 8 and a sewage lift pump provided. This relocation is described in section 6, Interior Drainage. The only other existing sewer line affected is the one along LR 310. Six manholes, indicated in plates 6 and 7 will be raised from 1 to 10 feet to clear the fill of LR 310. An 8-inch sewer line crossing of the Northkill Creek from the Heidelberg Inc. development to MH 57, as shown on plate 7, is required of Heidelberg Inc. by the Pennsylvania Department of Environmental Resources but plans have not yet been finalized and construction date has not been determined. Design of the sewer crossing will be coordina-

ted with the District. If this crossing is constructed prior to the dike construction, it is proposed to require construction compatible with the planned dike. The additional costs, over the cost of the crossing without the dike, will be paid as an advanced relocation. Relocation of the sewer constructed without regard to the future dike construction would be more costly than providing for dike in the initial sewer construction.

8-05 METROPOLITAN EDISON COMPANY FACILITIES.

a. Existing Facilities. The facilities of the Metropolitan Edison Company, which will be affected by the construction of Bernville protective works, are shown on plates 5 through 8 and must be relocated and/or adjusted to accommodate raising of the roads and provide line clearances required by the National Electric Safety Code and ER 1110-2-4401 over the levee and flood waters. The affected facilities in each area are described in detail as follows:

(1) Plates 5 through 7. Approximately 3,200 linear feet of 13.2 KV three-phase pole line along LR 310 must be relocated because of levee construction and the raising of LR 310. It is proposed to relocate the line to the eastward beginning at the south end of the LR 310 Northkill Creek Bridge, skirt the east toe of the levee to LR 06017, then east along LR 06017 across its intersection with T-715 as shown on plate 5. The relocated line will then turn south on an existing pole lines along T-715 and Main Street to Fourth Street where it will turn west to rejoin the existing line along LR 310. The existing pole line extending across Northkill Creek from LR 310 at Fourth Street westward to T623 will be raised for about 400 feet to clear the levee and relocated Northkill Creek.

(2) Plate 7. It will be necessary to relocate about 300 feet of pole line to avoid the access road to the top of the dike from the pumping plant. The pole line extending west from LR 310 across the levee and Northkill Creek to LR 06020 is to be abandoned. This abandonment is covered in DM 12, Part II, Utility Relocations.

c. Attitude of Owner. The owner is in essential agreement with the proposed plan of relocations.

d. Relocation Contract. The standard form of cost-reimbursable contract will be used for the required relocations of Metropolitan Edison Company for the Blue Marsh Lake Project.

8-06 BETHEL & MT.AETNA TELEPHONE & TELEGRAPH COMPANY FACILITIES.

a. Existing Facilities. The facilities of the Bethel & Mt. Aetna Telephone and Telegraph Company which will be affected by

the construction of the Bernville protective works are shown on plates 5 through 8 and described under the following paragraphs. Cost estimates are presented in table 4.

b. Proposed Relocations. Certain facilities of the company, located in the areas shown on plates 5 through 8, must be relocated and/or adjusted to accommodate raising of the roads and provide line clearances required by the National Electric Safety Code and ER 1110-2-4401 over the levee and flood waters. The affected facilities in each area are described in detail as follows:

(1) Plate 5. Approximately 960 linear feet of pole line, along LR 06017 from the intersection with T 715 to LR 310 and along LR 310 north to the Northkill Creek Bridge, must be relocated because of the raising of LR 06017 and the construction of the levee along LR 310. It is proposed to relocate the pole line across the intersection of LR 06017 and T 715 to the eastern toe of the levee and along the levee north to the end of the dike and then westward to tie into the existing line along LR 310 at the Northkill Bridge.

(2) Plate 7. The pole line along the relocated LR 310 northward from Fourth Street, Station 725 to Station 733, will be abandoned as houses served by this line will be removed and service no longer required. The toll line along Third Street, Fisherman's Lane and proceeding across the levee and Northkill Creek to LR 06020 and Womelsdorf, is relocated along Fourth Street and continuing across the levee and relocated Northkill Creek will be placed underground in ducts beneath the dike and Northkill Creek. The Cost of one-half of this 400 feet of duct was covered in DM 12, Part II, Utility Relocations. The other half, included in this DM cost estimate, was covered in DM 11, Highway Relocations, but will be deleted in a forthcoming revision.

(3) Plate 8. Another toll line along Third Street and Fisherman's Lane which proceeds across the levee and Northkill Creek to Robesonia Road and Robesonia, is relocated along LR 310. This relocation is covered in DM 12, Part II, Utility Relocations.

c. Attitude of Owner. The owner is in essential agreement with the proposed plan of relocations.

d. Relocation Contract. The standard form of cost-reimbursable contract will be used for the required relocations of the Bethel & Mt. Aetna Telephone & Telegraph Company for the Blue Marsh Lake Project.

SECTION 9
REAL ESTATE

9-01 GENERAL DESCRIPTION. The protective works borders on the Borough of Bernville, which it protects. Starting at the southern end of the project, the land west of the sewage treatment facility is affected. The land is partially wooded and is basically within the flood plain of the Northkill Creek. North of this area, a few residential properties begin to become affected in addition to the low lands along both sides of the creek. Further north, in addition to the aforementioned areas, Pennsylvania Route 183 (LR 130) will be relocated and elevated. These effects extend to the northernmost end of the protective works project.

9-02 REAL ESTATE REQUIREMENTS. The real estate requirements for Bernville Protective Works remain essentially the same as presented in Design Memorandum No. 7, Real Estate and Supplement No. 1. However, there has been an increase in flowage easement required, but there is a decrease in the fee take area. Additional construction easement areas will also be required. These changes will be fully addressed in a future supplement to Design Memorandum No. 7, Real Estate.

SECTION 10
SCHEDULE FOR DESIGN AND CONSTRUCTION

10-01 CONSTRUCTION SCHEDULE. The design and construction schedule for the Bernville Protective Works of the Blue Marsh Lake Project is indicated schematically in table 6. The period shown between the fourth quarter of fiscal year 1976 and the first quarter of fiscal year 1977 represents a transitionary or change-over period for the purpose of beginning a new system of Federal fiscal funding which will begin each fiscal year on 1 September instead of the previously used system of beginning on 1 July. Listed in order of sequence on the left side of the table are the six major categories which comprise this particular construction schedule. This schedule is based on the following assumptions:

a. Design Memorandum 13, Bernville Protective Works will be reviewed by higher authority by the middle of April 1975.

b. Upon the approval of DM 13, the plans and specifications will be prepared and submitted for approval by the middle of March 1976.

c. The contract and award procedures will begin in 1 July 1976 with award by 1 September 1976. There will be approximately a 30-day period between the contract award and the commencement of actual construction. Present funding levels preclude advertising of construction contracts for protective works prior to transition period between fiscal year 1976 and 1977.

d. Project construction would require two full years. Once construction is completed, impoundment can begin. The impoundment date as presently scheduled will be November 1978.

e. The construction schedule assumes the availability early in the construction phase of the four 90,000-gallons-per-minute storm water pumps. These pumps will require at least 1 year to procure. A determination will be made subsequent to approval of the Design Memorandum as to whether advance procurement on long lead items will be accomplished by the Government. The levels of funding and other factors will influence this decision.

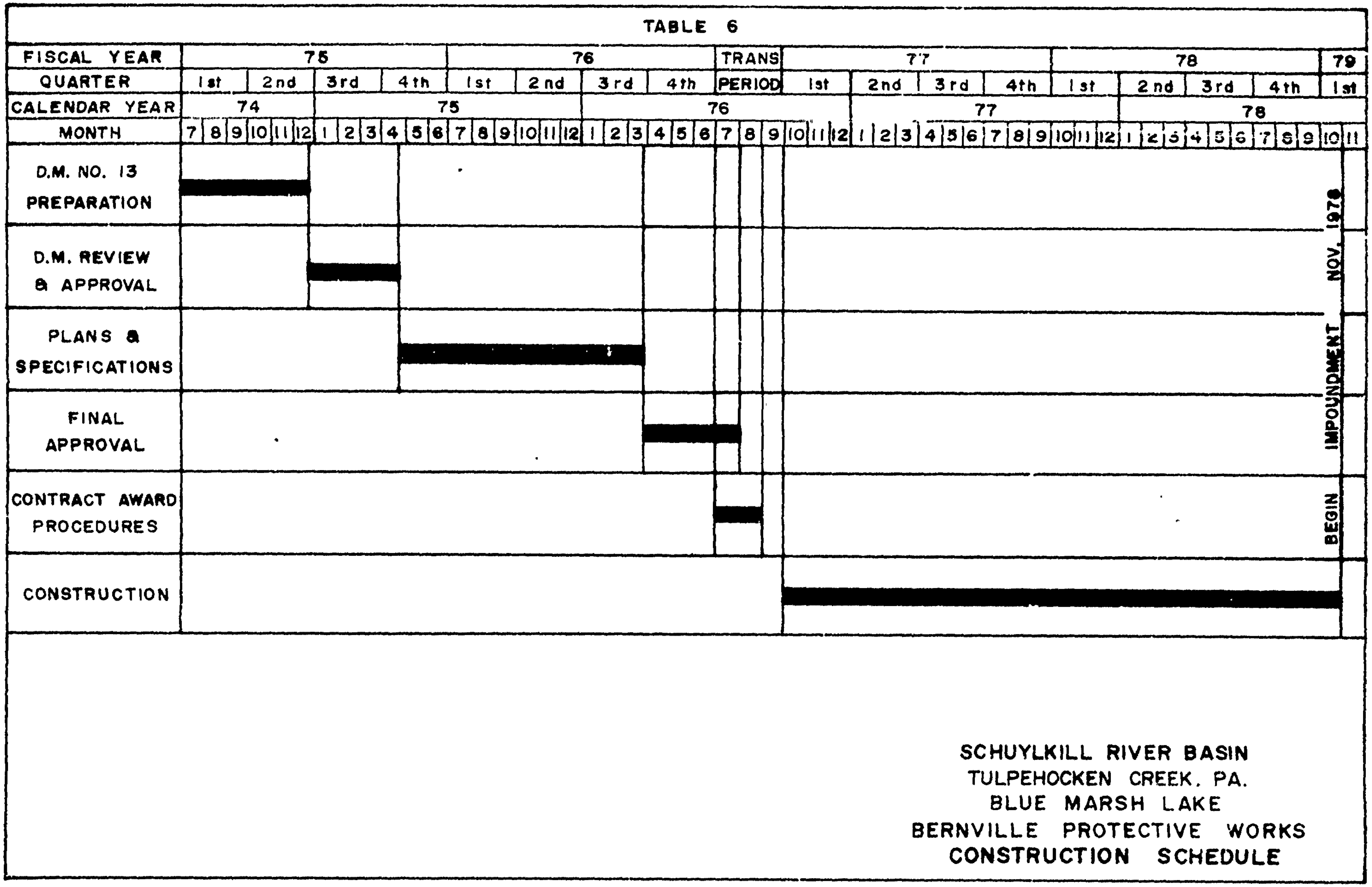


TABLE 6
FISCAL YEAR
75
76
TRANS PERIOD
77
78
79
QUARTER
1st
2nd
3rd
4th
CALENDAR YEAR
74
75
76
77
78
MONTH
7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11
D.M. NO. 13 PREPARATION
D.M. REVIEW & APPROVAL
PLANS & SPECIFICATIONS
FINAL APPROVAL
CONTRACT AWARD PROCEDURES
CONSTRUCTION
BEGIN IMPOUNDMENT NOV. 1978
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
CONSTRUCTION SCHEDULE

SECTION 11
OPERATION AND MAINTENANCE

11-01 OPERATION. The Federal Government will be responsible for operating and maintaining all features of the Bernville Protective Works except roads, bridges and utilities which will be turned over to the proper owner after construction. Internal drainage features include one pump station, which will function automatically during high river stages. During low river stages, which will be the case most of the time, internal drainage will flow out through a drainage culvert under the levee.

At high reservoir stages established in the Operation and Maintenance Manual, the dam operator or his assistant will insure that the sluice gates in the drainage structures are sealed to prevent backflow from the reservoir. At extremely high reservoir elevations, sandbagging will be required across Route 183 (LR 310) at one point. Bags for this operation will be stored in the pump station.

Operation of the Bernville Protective Works will require an estimated 250 man-hours annually. Operation costs attributable to this feature are expected to average $4,500 annually. If special utility rates for pumping stations as discussed in EM 1110-2-3101, "Pumping Stations - Local Cooperation and General Considerations" are not available, the operational costs for the project could increase substantially.

11-02 MAINTENANCE. The inside slope of the levee will be covered by grass, which will be mowed twice annually. Cleaning and maintenance of the sumps and pumps will be required after each flood stage operation. In addition, the pumps should be tested at least on a quarterly basis. The debris basin at the intake structure should be cleaned on an average of once every two years. Maintenance of the protective works will require at least 100 man-hours annually for grass and weed control. Maintenance of pumps and sumps will require an estimated 50 man-hours annually. Annual maintenance costs attributable to the protective works are expected to average about $2,500.

SECTION 12
COST ESTIMATES

12-01 COST INDICES. The construction costs in this memorandum are based on the prevailing prices in the Philadelphia-Reading, Pennsylvania area. The cost estimate was prepared using November 1974 price levels. The project cost estimate (Pb-3), dated 1 July 1974, was projected to November 1974 cost levels using the Engineering News Record-Construction Cost Index (ENR-CCI). The ENR-CCI for July 1974 was 2035.5 and for November 1974 was 2095.3. As a portion of Design Memorandum No. 11, Highway Relocations, must be used in the present comparison of costs, the costs contained therein, dated July 1973, were brought to November 1974 levels using the ENR-CCI of 1901 and 2095.3, respectively.

12-02 COST ESTIMATE. The cost summary and itemized cost estimates are shown in tables 7 and 8, respectively. The estimates are subject to revisions by: (a) developments at the time of negotiation with the Pennsylvania Department of Transportation for the relocation of Pa. Route 183 through Bernville, (b) revisions to design criteria, and (c) price level changes.

TABLE 7

CONSTRUCTION COST ESTIMATE SUMMARY

Cost Account	Project Component	Estimated Cost (Rounded)
02.	Relocations	$ 995,000.
.1	Roads	(914,000.)
.2	Utilities	(81,000.)
06.	Fish and Wildlife Facilities	$ 8,000.
11.	Levees and Floodwalls	$3,039,000.
13.	Pumping Plant	$2,743,000.
30.	Engineering and Design	$ 479,000.
31.	Supervision and Administration	$ 328,000.
	Total Federal Cost	$7,592,000.

12-03 COMPARISON OF COSTS WITH PROJECT ESTIMATE. The estimated construction cost included in the current approved Project Cost Estimate (Pb-3), dated 1 July 1974 for Blue Marsh Lake contains $3,429,000 for the Bernville Protective Works. Updated to November 1974 price levels, this amount is $3,529,000. The present estimated construction cost, including contingencies is $6,785,000.

The increase in costs from the Project Estimate to the present estimate are attributable to the following:

a. The Pennsylvania Department of Transportation's (PennDOT) criteria requires widening of the highway portion of the levee. The General Design Memorandum had a levee crest width of 48 feet, while a 60-foot width is now needed. This change also requires the widening of an additional portion of Northkill Creek.

b. Additionally, PennDOT's criteria caused the relocation of Pa. Route 183 (L.R. 310, Segment 6) within the Bernville area to be lengthened. Also, additional access roads and ramps to Route 183 are now required. (A portion of these costs were shown in Design Memorandum No. 11, Highway Relocations, both of which will be revised to show those costs attributable to the Bernville Protective Works. A similar revision of Design Memorandum No. 12, Utility Relocations, Part II, will be made for the relocation of the electric power and telephone lines for the Bernville area.) Raising of existing manholes and relocation of sanitary lines were not covered in any previous memorandums. The items are a result of better surveys and more detailed information.

c. The Pennsylvania Fish Commission has recently requested a meandering low water channel for fish in Northkill Creek. They also requested still water resting locations in the creek for the fish. These requirements were not known when the Project Plan was developed. The cost for this work is included in this memorandum.

d. When the General Design Memorandum was prepared, it was known the Borough of Bernville intended to construct a sewage treatment plant. This plant was to be located within or adjacent to the ponding area. As the exact plant location was unknown, a definitive design and costing of the interior drainage system and the ponding area with its resultant effect upon the pumping plant was excluded from the General Design Memorandum. The sewage treatment plant is now built and it alters the ponding area capacity. Additionally, concrete flood walls will have to constructed to protect this facility. Other items are similarly affected. The costs for these items are included in this memorandum.

e. Environmental enhancement and erosion control through extensive topsoiling, seeding, as well as plantings, were not required when the General Design Memorandum was prepared. The additional costs for these

items are now included in this memorandum.

f. The pumping plant capacity requirements have increased from 200,000 g.p.m. to 360,000 g.p.m. principally as a result of the decreased ponding area and more detailed hydrological studies. A new power line is required to furnish a reliable and adequate power supply for the pumping plant. Presently, sufficient power is not available in the vicinity of the pumping plant. (The existing power line was adequate for a 200,000 g.p.m. plant, but recent information casts substantial doubt on the existing power system's reliability.) The estimate has been revised accordingly.

TABLE 8
DETAILED COST ESTIMATE
(November 1974 Price Levels)

Cost Account No.	Item	Unit	Quantity	Unit Cost	Total Cost (Rounded)
01	LANDS AND DAMAGES				
	(To be furnished at a later date, as supplement to Real Estate Design Memorandum No. 7)				
02	RELOCATIONS				
	.1 Roads				
	Raising L.R. 310 at Levee	L.S.	-	Job	$ 470,500.
	Raising L.R. 06017 at Levee	L.S.	-	Job	63,600.
	Raising T-715 at Levee	L.S.	-	Job	22,000.
	Drainage (Prorated with Levee Drainage)	L.S.	-	Job	85,000.
	Topsoil, Seed & Mulch Side slopes	L.S.	-	Job	5,000.
	Maintain & Protect Traffic	L.S.	-	Job	150,000.
	Roadside Development	L.S.	-	Job	20,000.
				Subtotal	$ 816,100.
	Contingencies	12%			97,900.
		Total Roads Cost			$ 914,000.
	.3 Utilities				
	Sanitary Lines	L.S.	-	Job	$ 11,500.
	Raise Existing Manholes	L.S.	-	Job	6,000.
	Electric Power Lines	L.S.	-	Job	15,600.
	Telephone Lines	L.S.	-	Job	39,500.
				Subtotal	$ 72,600.
	Contingencies	12%			8,700.
		Total Utilities Cost			$ 81,300.
		TOTAL RELOCATIONS COST			$ 995,300.
06	FISH AND WILDLIFE FACILITIES				
	Low Flow Stream Channel	C.Y.	3,100	$ 2.00	$ 6,200.
	Stillwater Boulders	Each	8	125.--	1,000.
				Subtotal	$ 7,200.
	Contingencies	12%			900.
	TOTAL FISH AND WILDLIFE FACILITIES COST				$ 8,100.

Cost Account No.	Item	Unit	Quantity	Unit Cost	Total Cost (Rounded)
11	LEVEES AND FLOODWALLS				
	Levee				
	Care and Diversion of Water	L.S.	-	Job	$ 80,000.
	Clearing & Grubbing	Acre	19	$1,200.	22,800.
	Excavation				
	Strip & Stockpile Topsoil from Foundations	C.Y.	32,800	1.75	57,400.
	Strip & Stockpile Topsoil from Borrow Area	C.Y.	40,000	1.75	70,000.
	Random	C.Y.	30,000	1.50	45,000.
	Rock	C.Y.	2,500	10.00	25,000.
	Waste	C.Y	65,400	1.50	98,100.
	Borrow				
	Random *	C.Y.	273,900	1.50	410,900.
	Impervious	C.Y.	105,800	1.50	158,700.
	Rock	C.Y.	500	10.00	5,000.
	Embankment				
	Random *	C.Y.	276,300	0.45	124,300.
	Impervious	C.Y.	92,000	0.45	41,400.
	Rockfill	C.Y.	3,600	0.50	1,800.
	Piezometers, Open-Type	L.S.	-	Job	10,000.
	Drainage Structure No. 1	L.S.	-	Job	87,500.
	Drainage Structure No. 2	L.S.	-	Job	28,700.
	Drainage Structure No. 3	L.S.	-	Job	29,300.
	Bedding	C.Y.	5,900	17.00	100,300.
	Riprap	C.Y.	19,400	22.00	426,800.
	Topsoiling	S.Y.	42,150	1.50	63,200.
	Seeding & Mulching	S.Y.	52,000	0.15	7,800.
	Ramp				
	Embankment	C.Y.	1,560	2.00	3,100.
	Subgrade Preparation	S.Y.	1,540	0.40	600.
	Levee Crown Surfacing, 8" depth	C.Y.	970	18.00	17,500.
	Subbase, 6" depth	S.Y.	1,240	2.00	2,500.
	Crushed Aggregate Base, $4\frac{1}{2}$" depth	S.Y.	1,190	3.75	4,500.
	Select Material Surfacing, 6" depth	S.Y.	260	3.00	800.
	Bituminous Surface Course, $2\frac{1}{2}$" depth	S.Y.	1,140	4.00	4,600.
	Guard Rail, Type 2-S	L.F.	180	12.00	2,200.
	Chain Link Fence, 8' high	L.F.	95	15.00	1,400.
	Flanking Levee				
	Stripping	C.Y.	1,000	1.50	1,500.

* Includes 4,500 c.y. (in place) of pervious fill to control seepage emergence on landside slope.

Cost Account No.	Item	Unit	Quantity	Unit Cost	Total Cost (Rounded)	
11	LEVEES AND FLOODWALLS (continued)					(1500
	Levee (continued)					
	Flanking Levee (cont'd)					
	Excavation, Common	C.Y.	400	1.50	$ 600.	
	Borrow					
	Random	C.Y.	7,500	1.50	11,300.	28,300
	Impervious	C.Y.	3,500	1.50	5,300.	
	Embankment					
	Random	C.Y.	7,200	0.45	3,200.	
	Impervious	C.Y.	3,200	0.45	1,400.	
	Topsoiling	S.Y.	3,000	1.50	4,500.	
	Seeding & Mulching	S.Y.	3,000	0.15	500.	
	Floodwalls and Interior Drainage					
	Stripping	C.Y.	2,360	1.50	3,500.	
	Excavation					
	Random (Culvert)	C.Y.	16,100	3.00	48,300.	62,000
	Random (Ditch)	C.Y.	875	2.25	2,000.	
	Rock	C.Y.	820	10.00	8,200.	
	Backfill					
	Random	C.Y.	13,200	3.00	39,600.	65,900
	Granular	C.Y.	2,020	13.00	26,300.	
	Floodwall					
	Concrete	C.Y.	490	150.00	73,500.	
	Reinforcement	Lbs.	44,130	0.40	17,700.	102,100
	Cement	Cwt.	2,760	2.50	6,900.	
	Misc. Metals	L.S.	-	Job	4,000.	
	Drainage					
	Concrete	C.Y.	439	125.00	54,900.	
	Reinforcement	Lbs.	6,330	0.40	2,500.	454,200
	Cement	Cwt.	2,270	2.50	5,700.	
	16'-5"x9'-11" BCCMP, 10 gage	L.F.	655	450.00	294,800.	
	11'-10"x7'-7" BCCGMP, 10 gage	L.F.	275	350.00	96,300.	
	Associated Minor Items					
	Topsoiling	L.S.	-	Job	8,000.	
	Seeding & Mulching	L.S.	-	Job	2,000.	
	Regrading	C.Y.	2,230	2.50	5,600.	

Cost Account No.	Item	Unit	Quantity	Unit Cost	Total Cost (Rounded)
11	LEVEES AND FLOODWALLS (continued)				
	Associated Minor Items (continued)				
	Landscaping	L.S.	-	Job	$ 31,000.
	Environmental Enhancement				
	Trails	L.F.	1,800	5.00	9,000.
	Footbridges (3)	L.S.	-	Job	5,000.
	Parking Areas	S.Y.	2,250	4.00	9,000.
			Subtotal		$2,713,300.
	Contingencies	12%			325,600.
	TOTAL LEVEES AND FLOODWALLS COST				$3,038,900.
			Say		$3,039,000.
13	PUMPING PLANT				
	Preparatory Work				
	Clearing and Grubbing	Acre	1	1,200.	1,200.
	Care of Water	L.S.	-	Job	9,000.
	Pumping Plant Substructure				
	Stripping	C.Y.	750	1.50	1,100.
	Excavation, Commom	C.Y.	23,000	2.25	51,800.
	Excavation, Firm Rock	C.Y.	4,700	10.00	47,000.
	Excavation, Weathered Rock	C.Y.	11,300	6.00	67,800.
	Backfill, Random	C.Y.	10,400	2.00	20,800.
	Foundation Preparation	L.S.	-	Job	3,000.
	Substructure Slab, Walls, Intake and Outlet Structures				
	Concrete	C.Y.	1,180	150.00	177,000.
	Reinforcing steel	Lbs.	97,150	0.40	38,900.
	Cement	Cwt.	6,100	2.50	15,300.
	Pumping Plant Superstructure	L.S.	-	Job	74,700.
	Pumping Machinery and Appurtenances				
	Main Pumps and Motors	Each	4	253,000.	1,012,000.
	Sump Pumps	Each	2	7,500.	15,000.
	Prestressed Concrete Discharge Piping	L.F.	860	100.	86,000.
	Flap Gates	Each	2	2,000.	4,000.
	Backflow Gates	Each	4	10,000.	40,000.
	Slide Gates with Operators	Each	4	60,000.	240,000.
	Intake Equipment				
	Trash Racks	Lbs.	18,400.	2.25	41,400.
	Auxiliary Equipment				
	Dehumidification	L.S.	-	Job	7,000.
	Misc. Mech. Work & Testing	L.S.	-	Job	50,000.
	Interior Electrical Work	L.S.	-	Job	112,000.

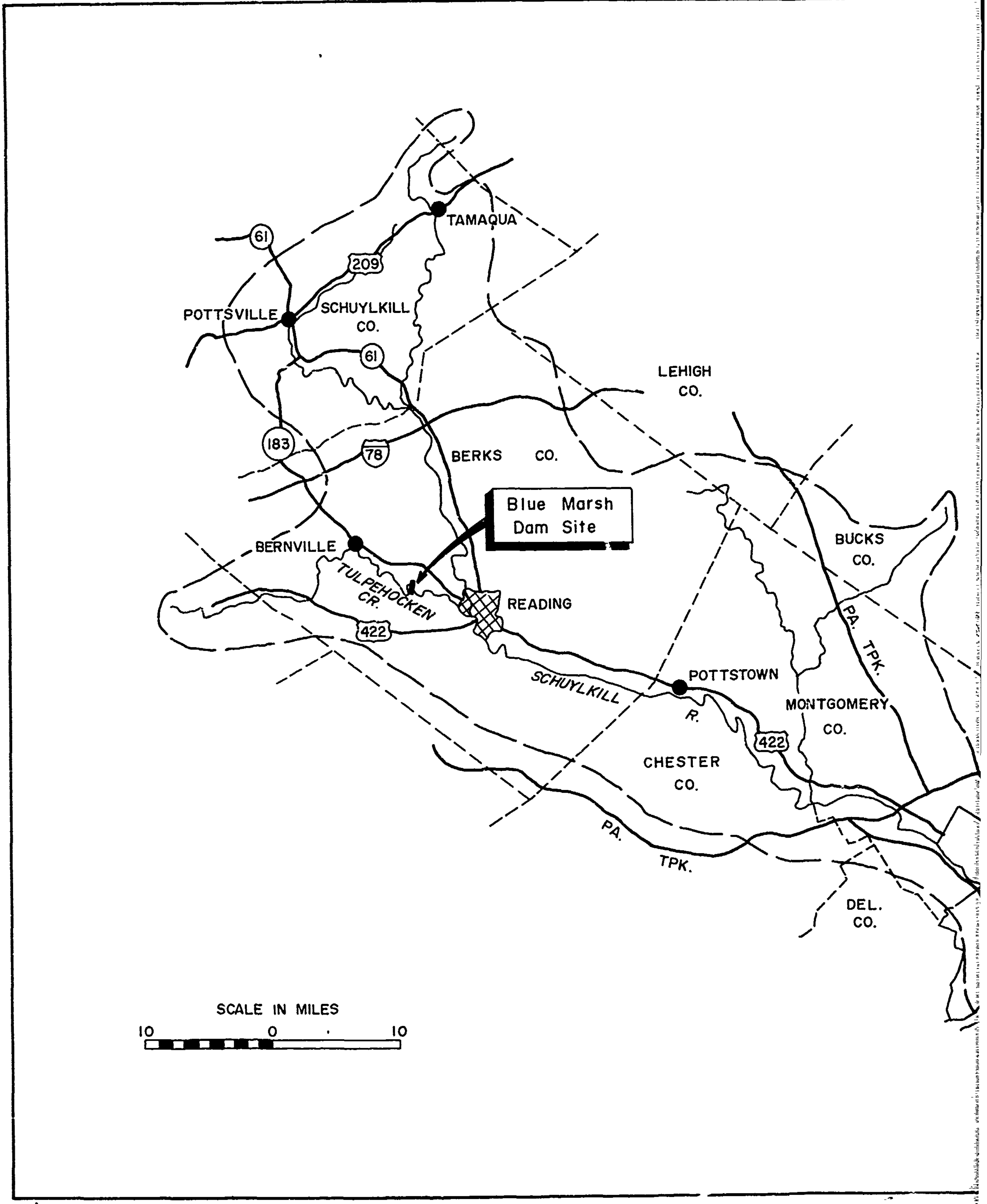
Cost Account No.	Item	Unit	Quantity	Unit Cost	Total Cost (Rounded)
13	PUMPING PLANT (continued)				
	Substation, including Ground Mat	L.S.	-	Job	$ 76,000. 96,000
	Misc. Electrical Work and Testing	L.S.	-	Job	20,000.
	Utilities				
	Telephone, Telephonic Stage Meters & Alarm	L.S.	-	Job	15,000. 180,000
	Power Supply Line	L.S.	-	Job	165,000.
	Intake Channel				
	Stripping	C.Y.	560	1.50	800.
	Excavation, Common	C.Y.	3,400	2.25	7,700.
	Excavation, Weathered Rock	C.Y.	930	6.00	5,600.
	Excavation, Firm Rock	C.Y.	100	10.00	1,000.
	Bedding	C.Y.	280	17.00	4,800.
	Riprap	C.Y.	840	22.00	18,500.
	Landscaping	L.S.	-	Job	20,000.
			Subtotal		$2,449,400.
	Contingencies	12%			293,900.
	TOTAL PUMPING PLANT COST				$2,743,300.
			Say		$2,743,000.

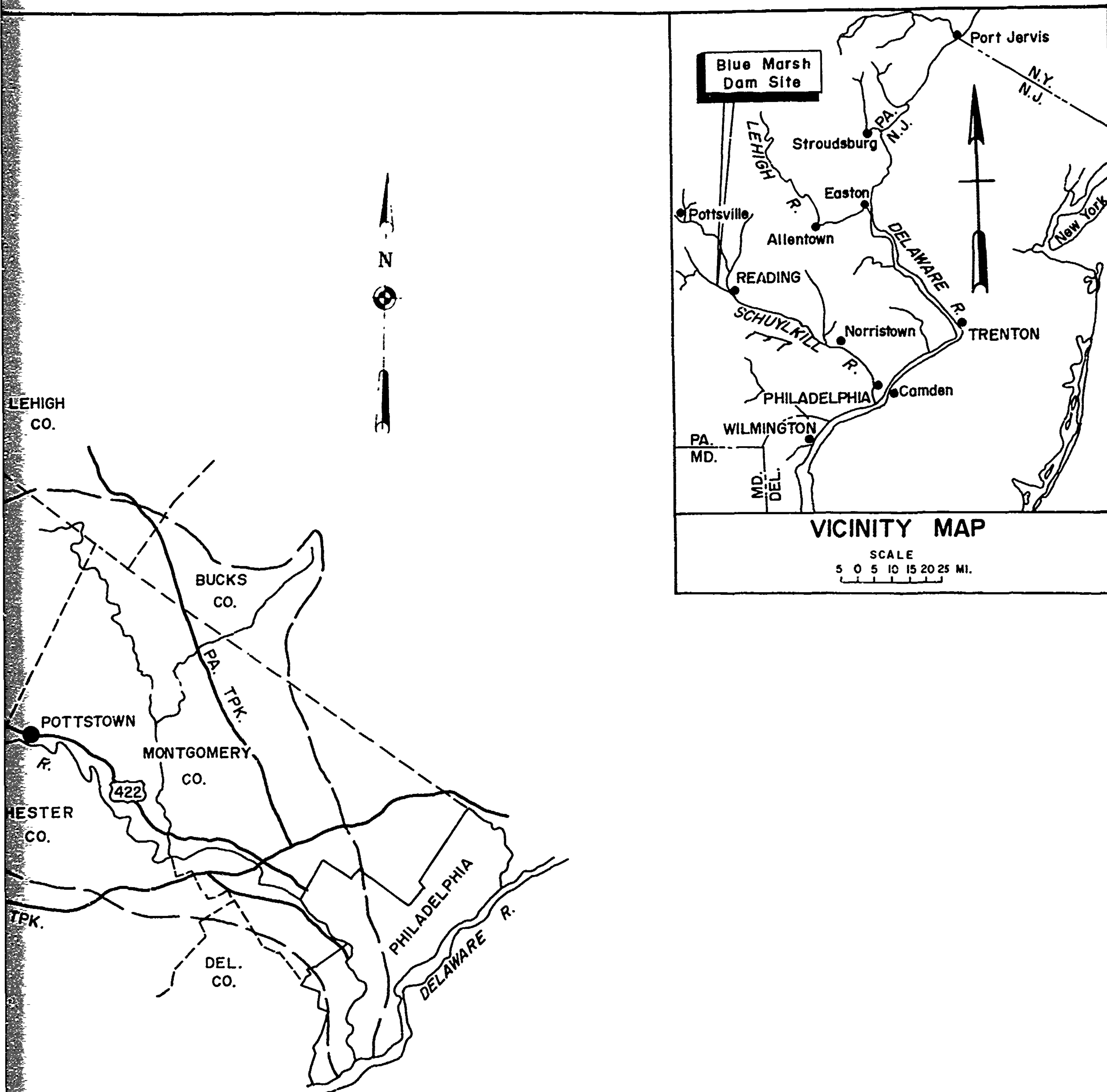
SECTION 13
RECOMMENDATIONS

13-01 APPROVAL OF PLAN. Construction of protective works for the Borough of Bernville is necessary to relieve that Community of flooding hazards created by construction of the Blue Marsh Dam. The plan of protection presented in this design memorandum is the most economical method which is acceptable to officials and utility owners, and is recommended for adoption.

Further, it recommended that this design memorandum be approved as the basis for preparation of relocation agreements with highway and utility owners and the preparation of contract plans and specifications.

CORPS OF ENGINEERS



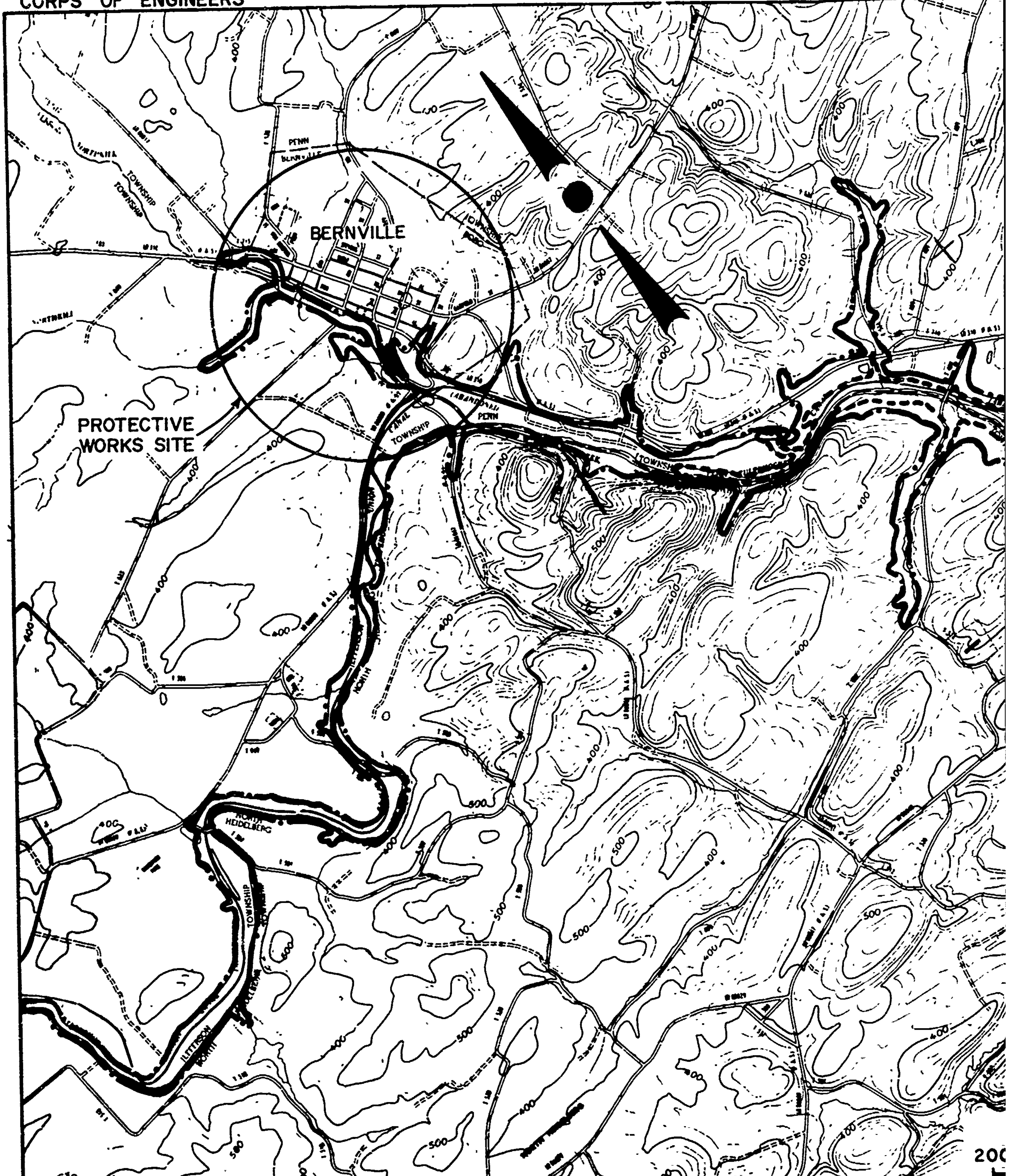


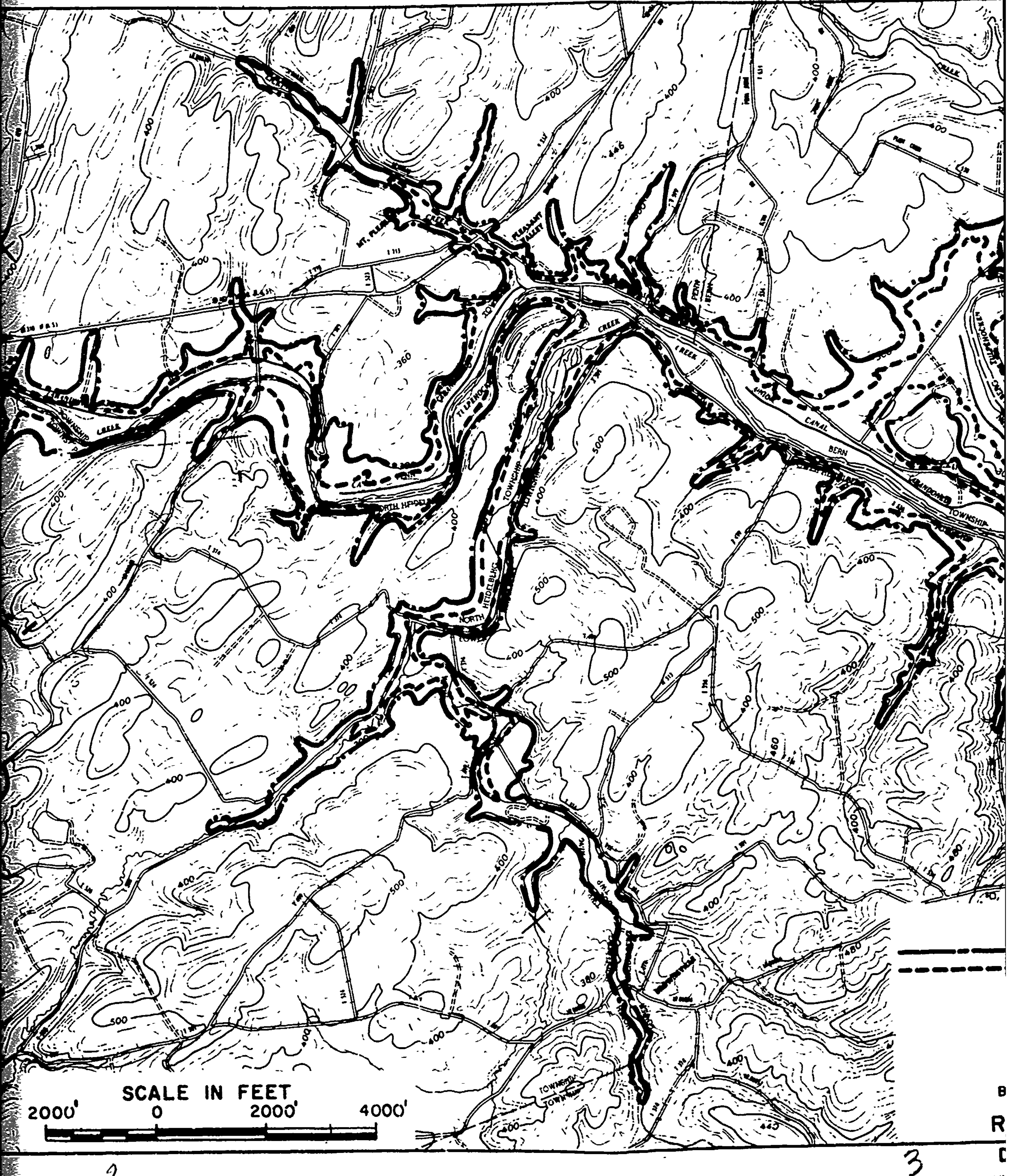
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

LOCATION MAP

D.M. NO. 13 PLATE I

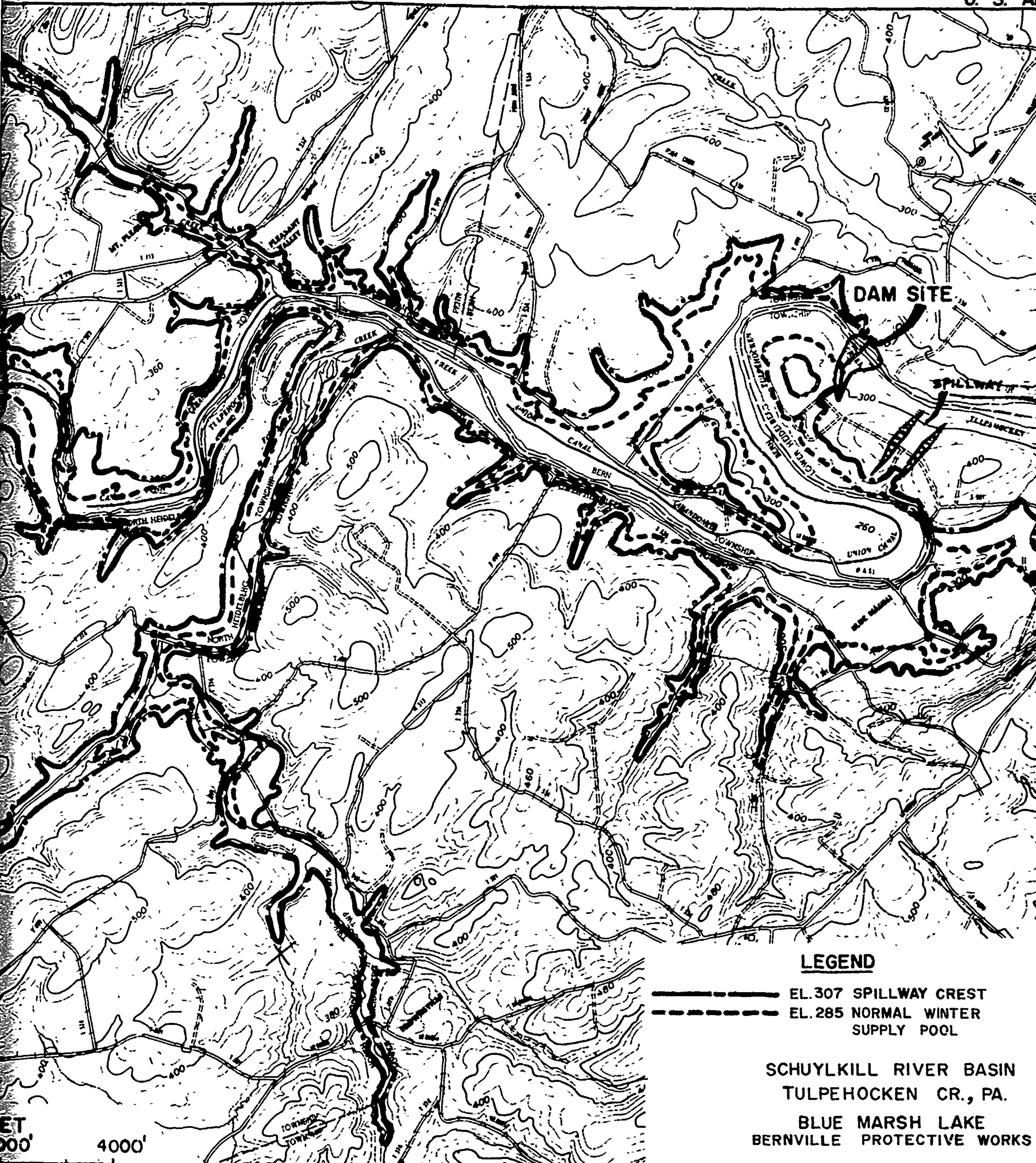
CORPS OF ENGINEERS




SCALE IN FEET
2000' 0 2000' 4000'
CREEK
TOWNSHIP
NORTH HEIDELBURG
NORTH HEIDELBURG
TOWNSHIP
CANAL
BERN
TOWNSHIP
LOWER
TULPEHOCKEN
PENN
400
500
360
446
460
380
480
440

2

3



LEGEND

EL. 307 SPILLWAY CREST

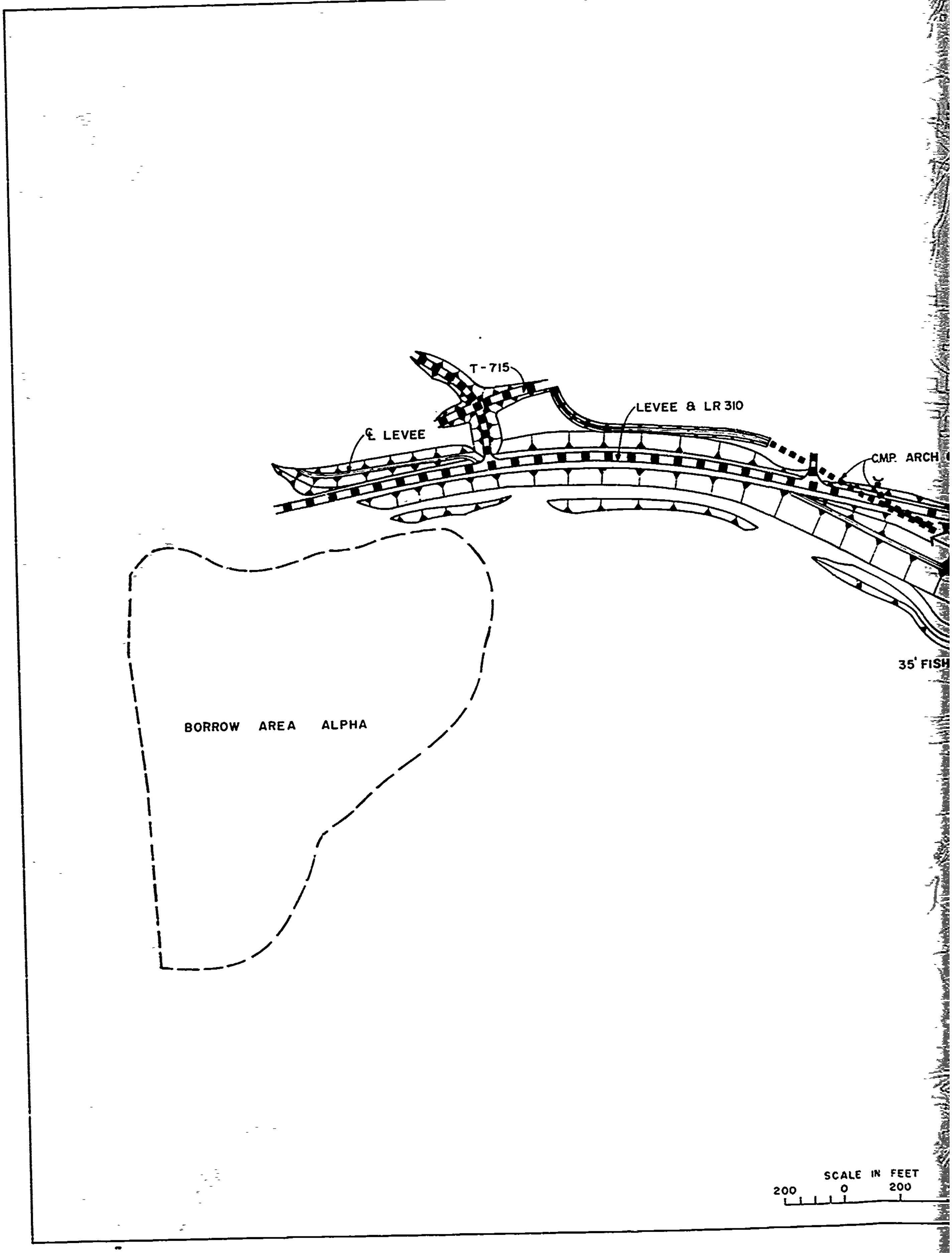
EL. 285 NORMAL WINTER SUPPLY POOL

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CR., PA.

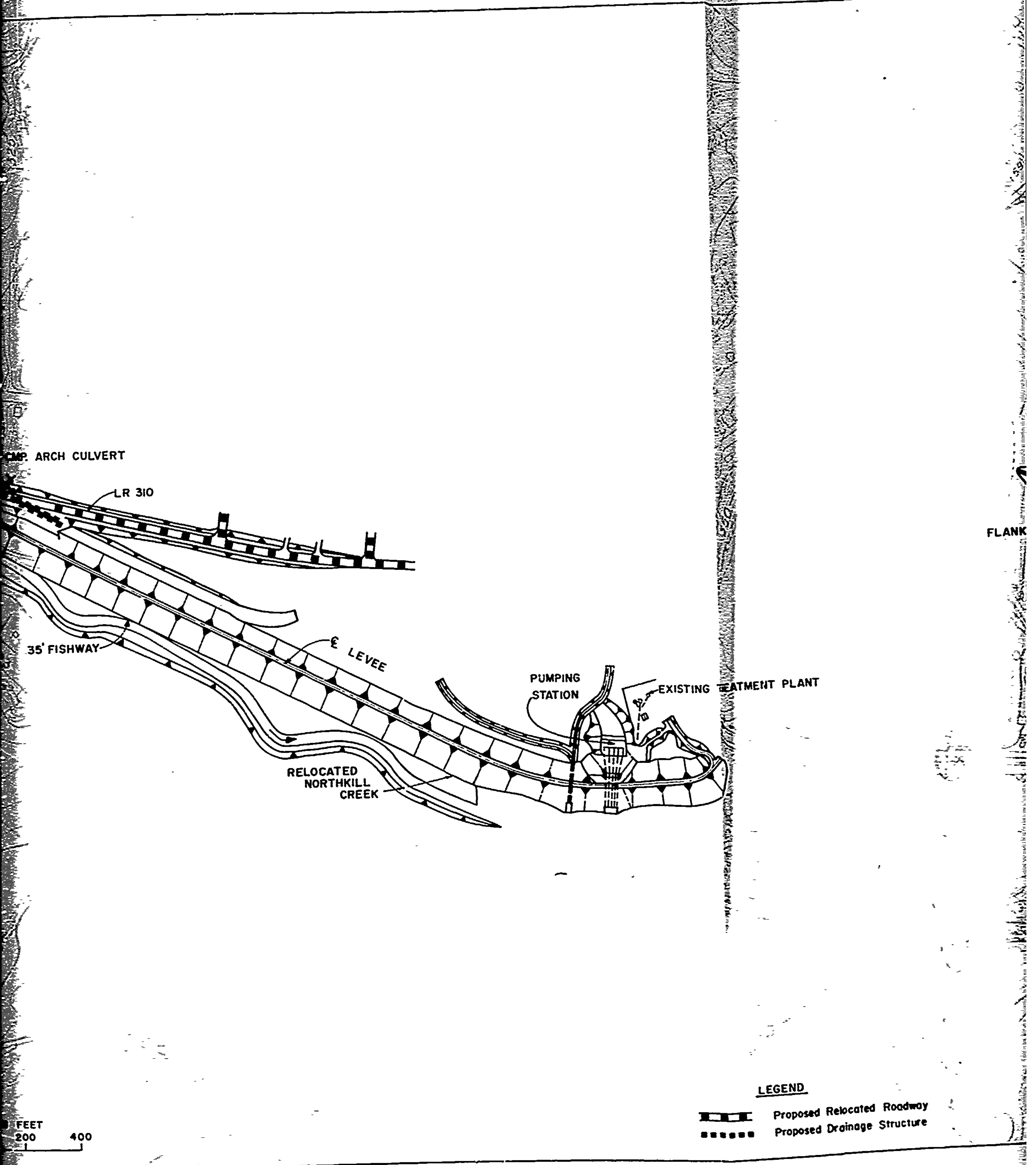
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

RESERVOIR POOL LEVELS

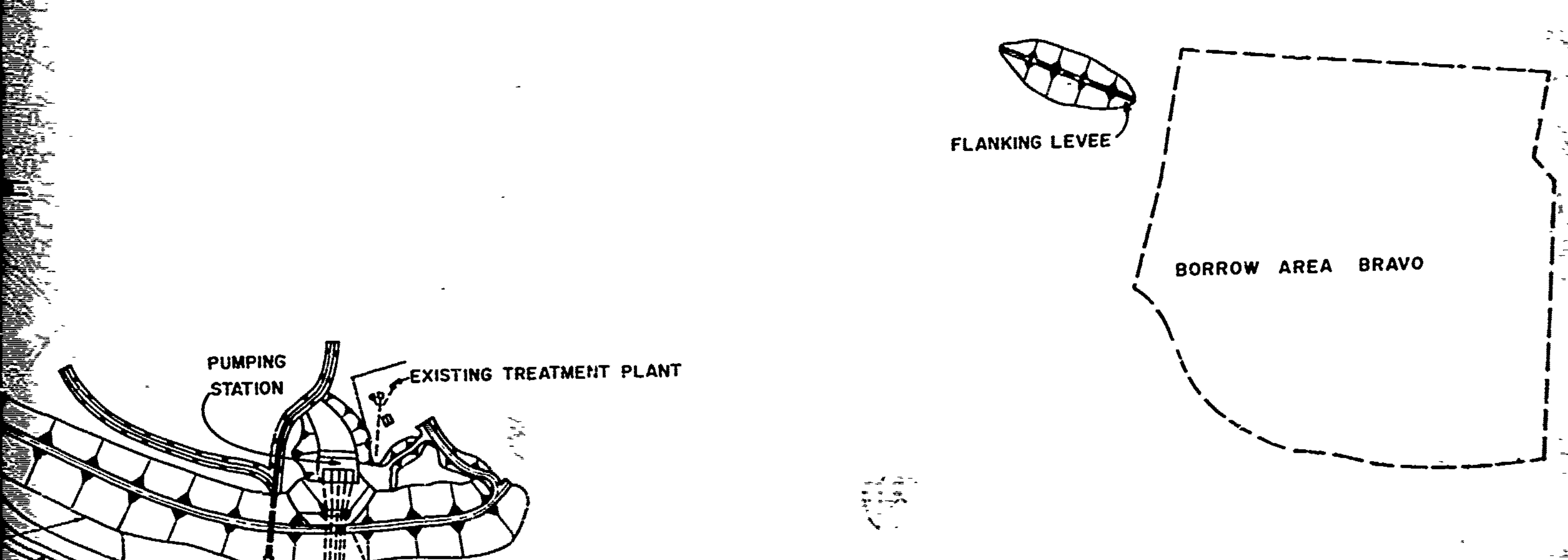
D. M. NO. 13 PLATE 2



T - 715
LEVEE & LR 310
℄ LEVEE
CMP. ARCH
35' FISH
BORROW AREA ALPHA
SCALE IN FEET
200 0 200



MP. ARCH CULVERT
LR 310
35' FISHWAY
℄ LEVEE
PUMPING STATION
EXISTING
ATMENT PLANT
RELOCATED NORTHKILL CREEK
FLANK
LEGEND
Proposed Relocated Roadway
Proposed Drainage Structure
FEET
200 400



LEGEND

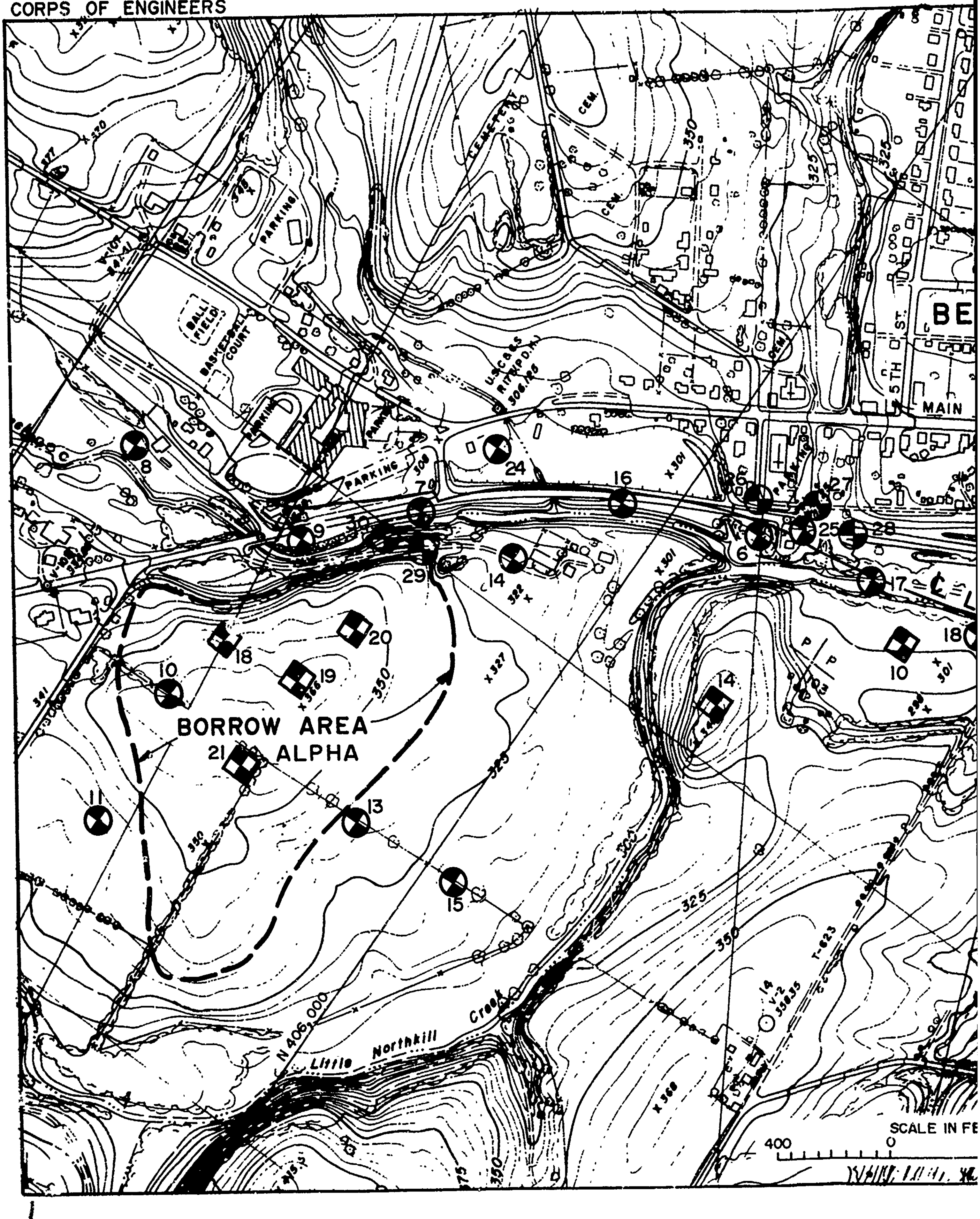
Proposed Relocated Roadway

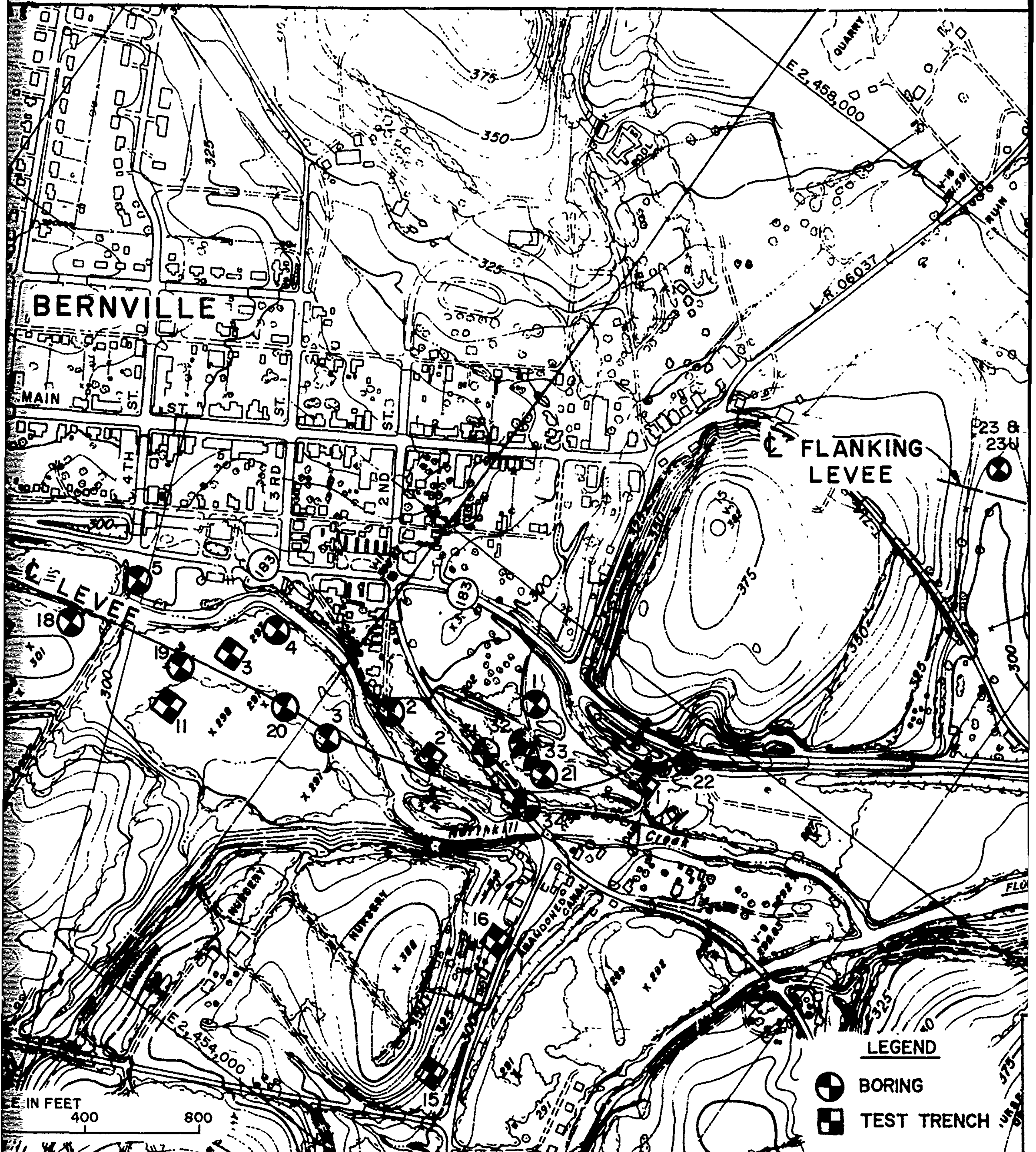
Proposed Drainage Structure

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
GENERAL PLAN

D.M. NO. 13 PLATE 3

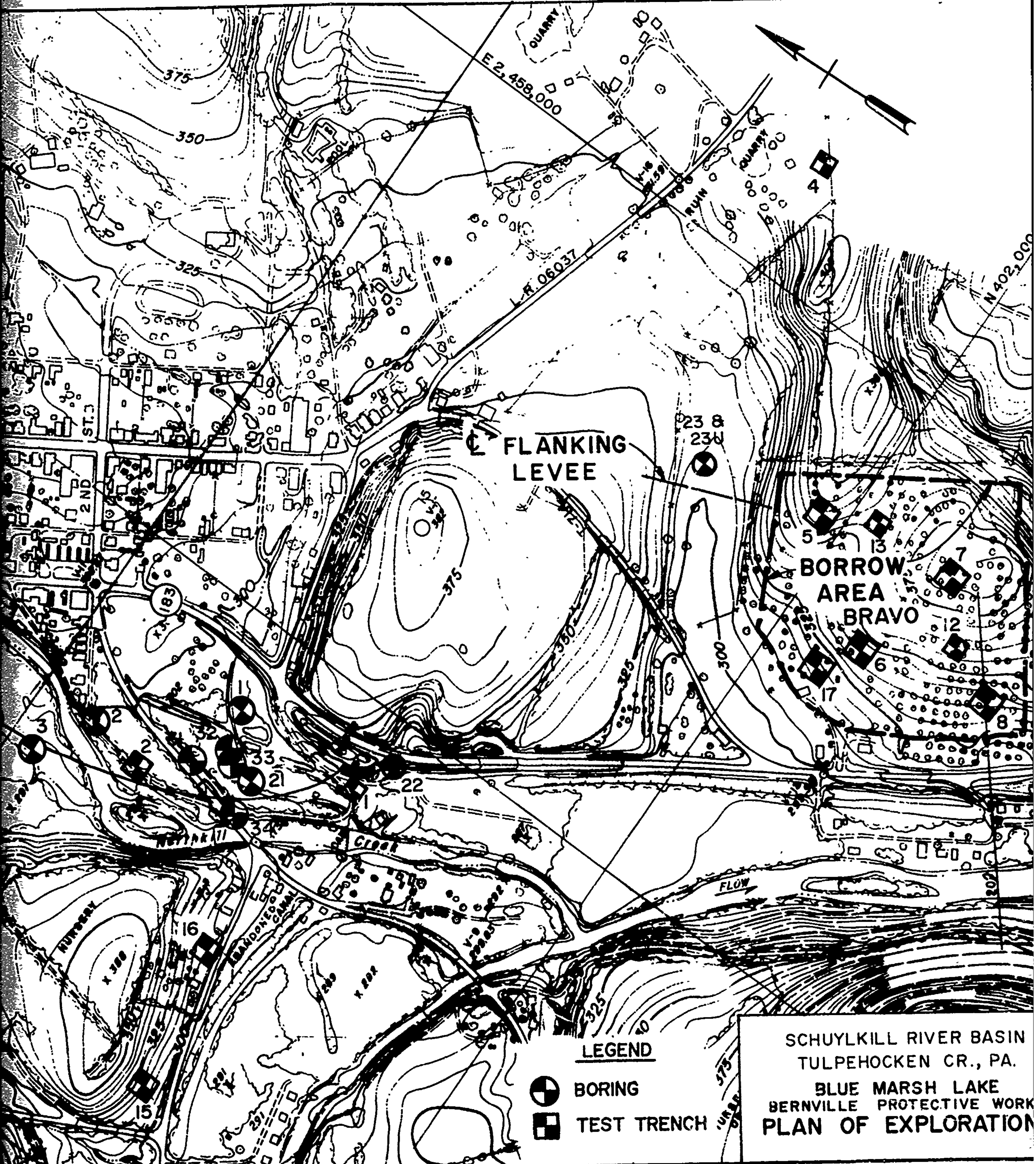
CORPS OF ENGINEERS



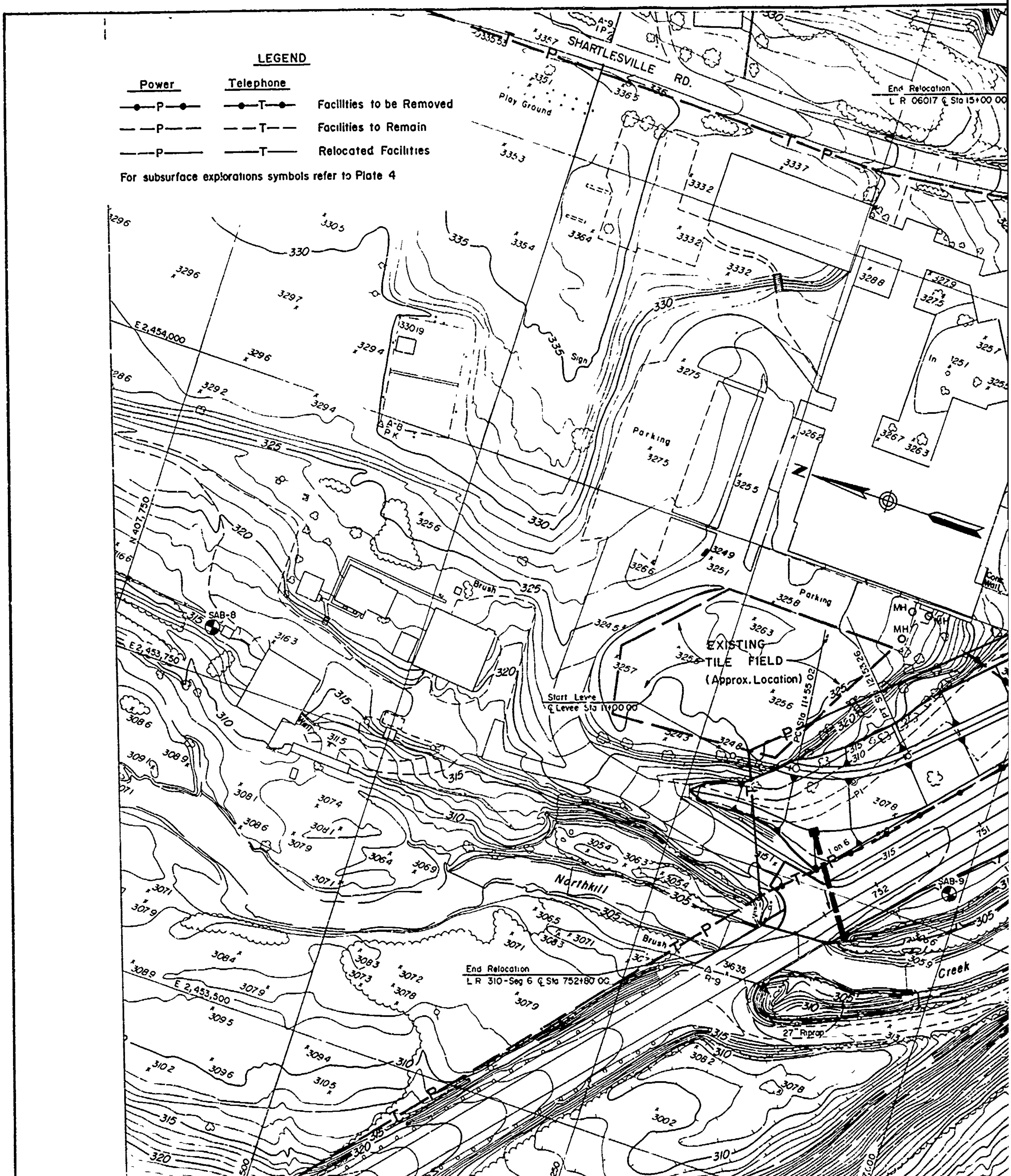

BERNVILLE
MAIN
ST.
4TH
3 RD
2 ND
375
350
325
300
E 2,458,000
QUARRY
L.R. 06037
RUIN
POOL
FLANKING
LEVEE
23 &
23U
LEVEE
183
5
18
19
3
4
11
20
3
2
2
1
32
33
21
22
34
NURSERY
ABANDONED CANAL
16
15
E 2,454,000
Creek
E IN FEET
400
800
LEGEND
BORING
TEST TRENCH

2

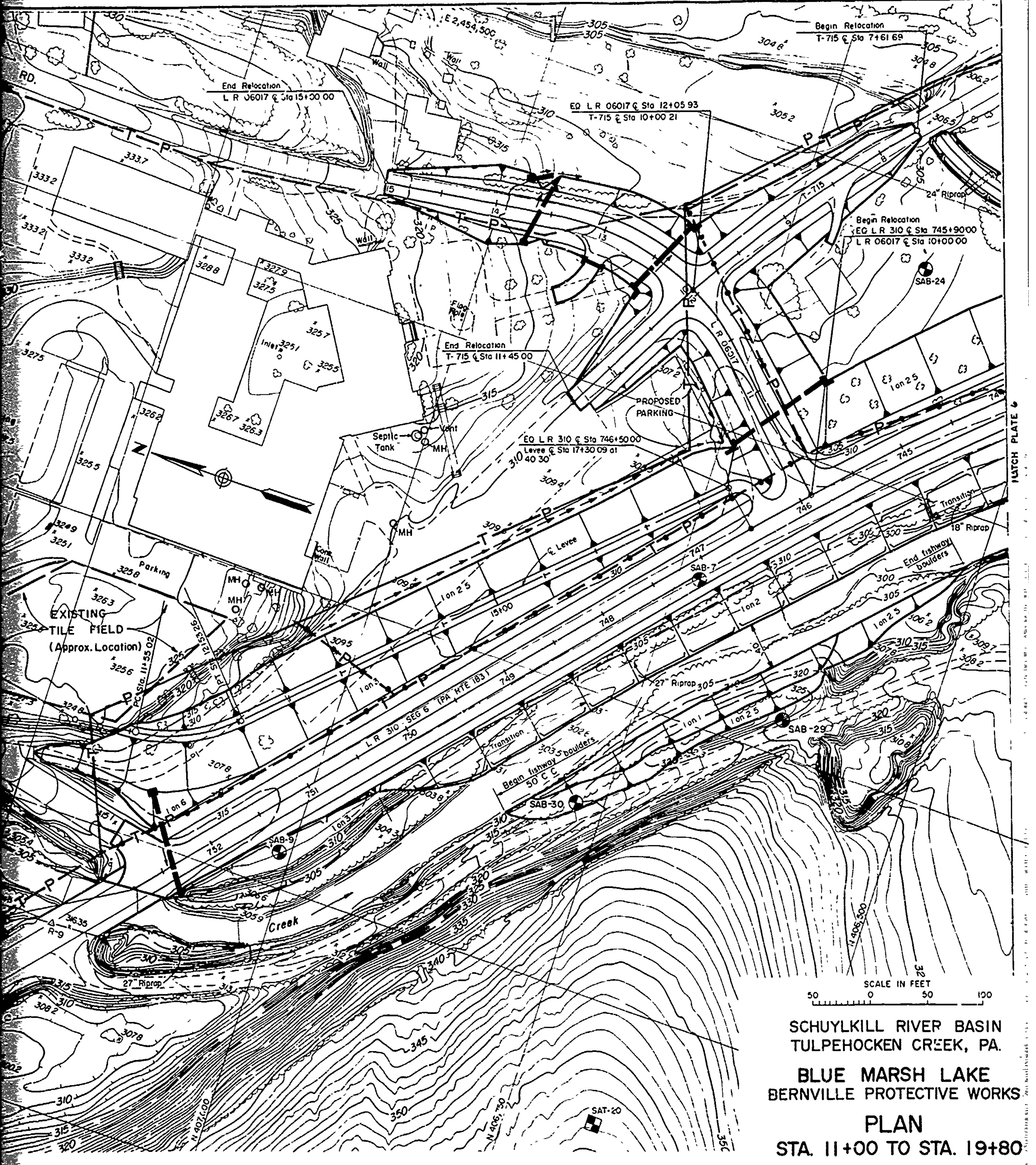
3



FLANKING LEVEE
BORROW AREA BRAVO
E 2,458,000
N 402,000
L.R. 06037
ST. 3
2 ND
183
QUARRY
RUIN
Creek
ABANDONED CANAL
NURSERY
FLOW
23 & 23U
LEGEND
BORING
TEST TRENCH
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CR., PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORK
PLAN OF EXPLORATION



LEGEND
Power
Telephone
Facilities to be Removed
Facilities to Remain
Relocated Facilities
For subsurface explorations symbols refer to Plate 4
SHARTLESVILLE RD.
Play Ground
End Relocation
L R 06017 ℄ Sta 15+00 00
Parking
EXISTING
TILE FIELD
(Approx. Location)
Start Levee
℄ Levee Sta 11+00 00
Northkill
Creek
Brush
End Relocation
L R 310-Seg 6 ℄ Sta 752+80 00
27" Riprap
SAB-8
SAB-9
E 2,454,000
E 2,453,750
E 2,453,500
N 407,750
N 407,500
N 407,250
N 407,000
Sign

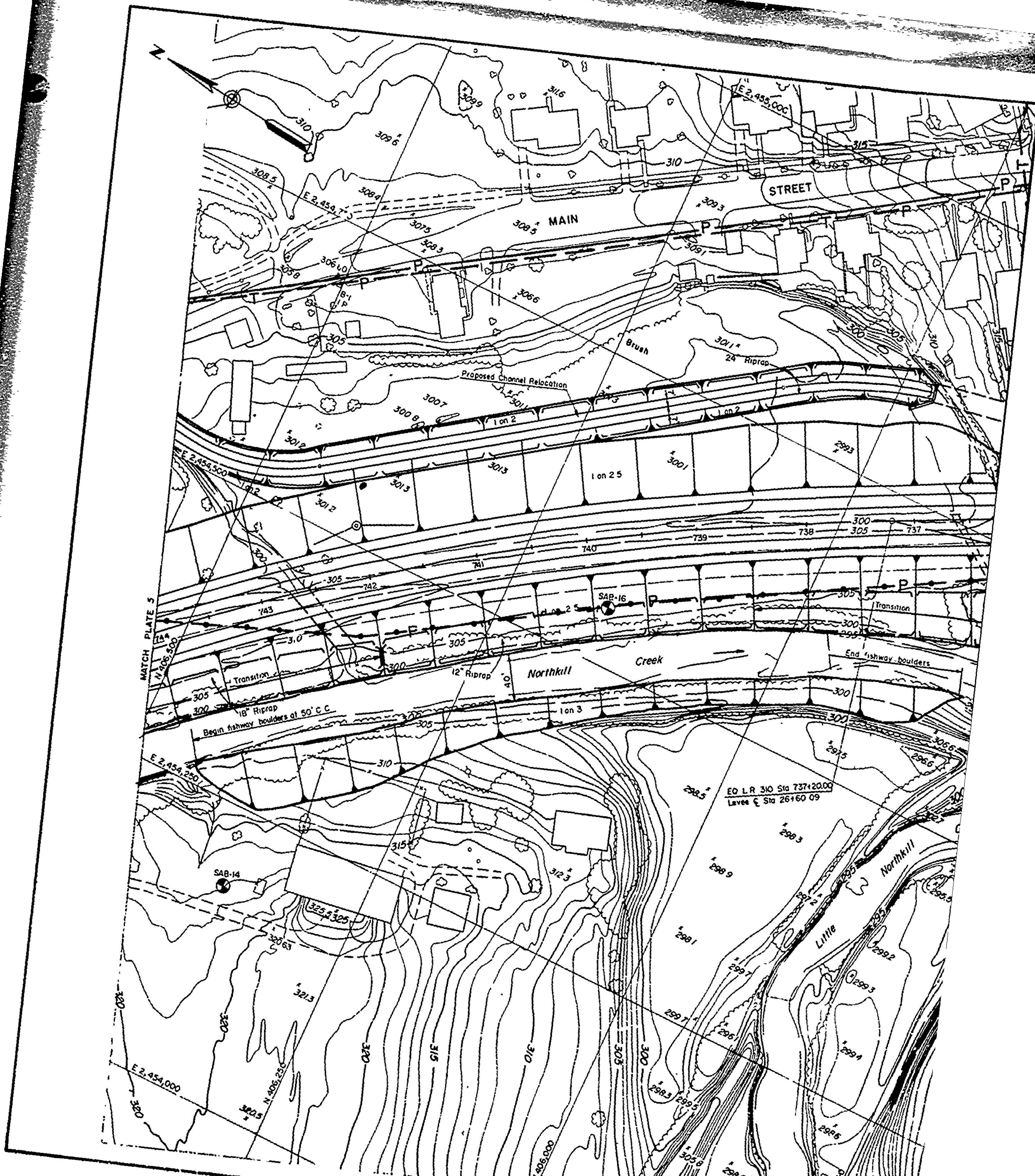


SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

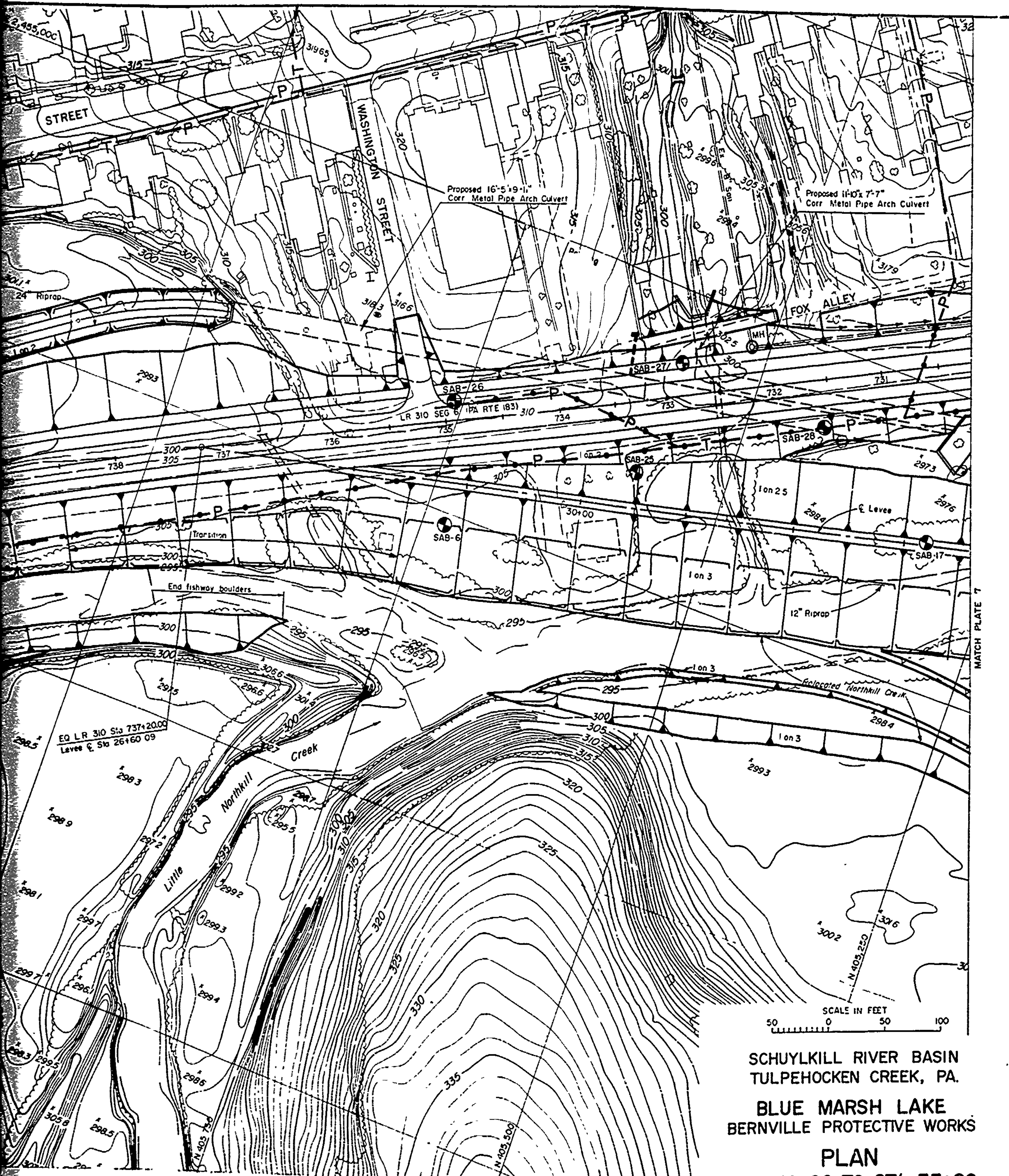
PLAN
STA. 11+00 TO STA. 19+80

D.M. NO. 13 PLATE



MAIN
STREET
Brush
24" Riprap
Proposed Channel Relocation
1 on 2
1 on 25
Transition
SAB-16
Northkill
Creek
12" Riprap
18" Riprap
Begin fishway boulders at 50' C C
End fishway boulders
1 on 3
EO L R 310 Sta 737+20.00
Levee ℄ Sta 26+60 09
SAB-14
Little
Northkill
MATCH PLATE 5
E 2,455,000
E 2,454,750
E 2,454,500
E 2,454,250
E 2,454,000
N 406,500
N 406,250
N 406,000
N 405,750

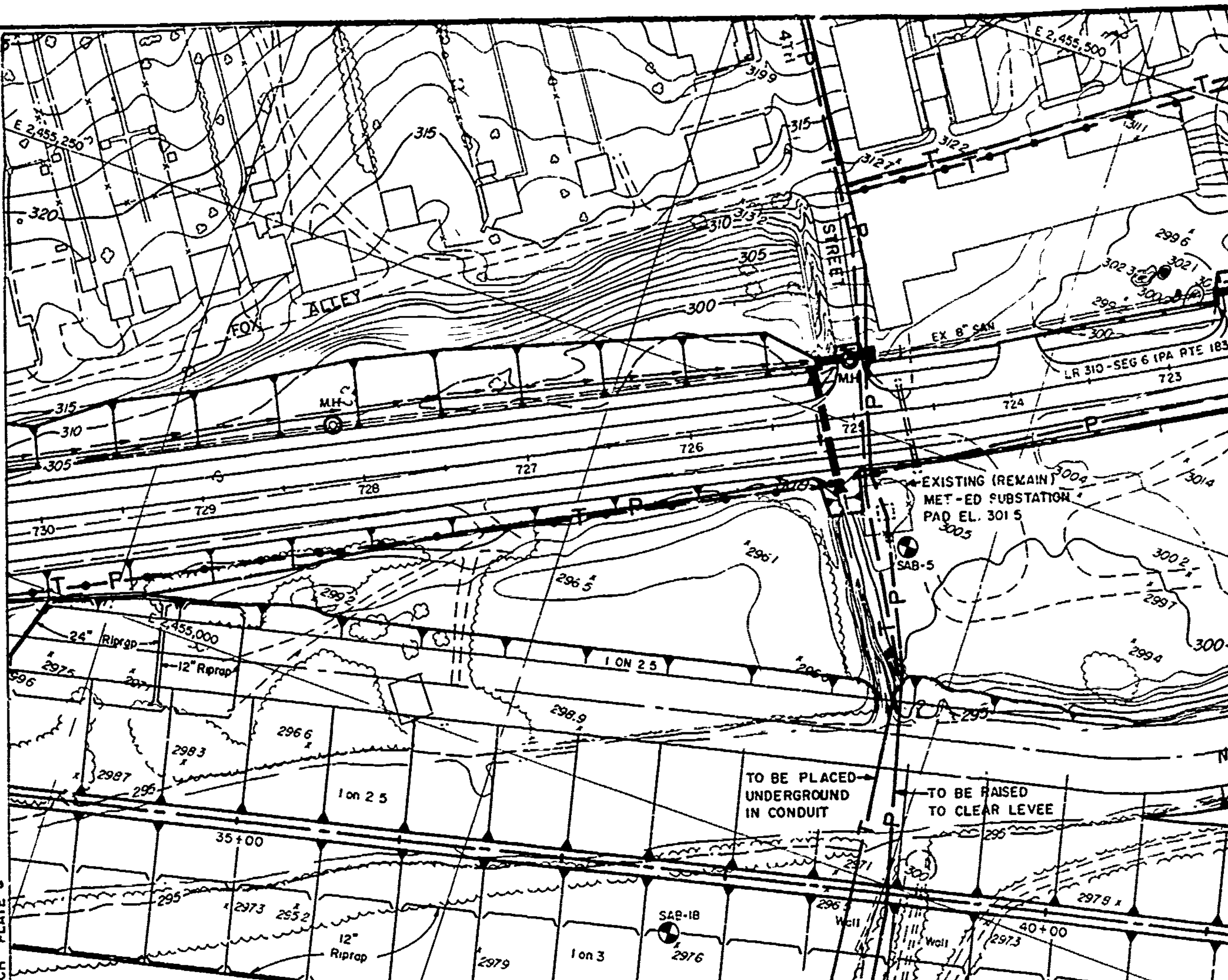
FOR LEGEND



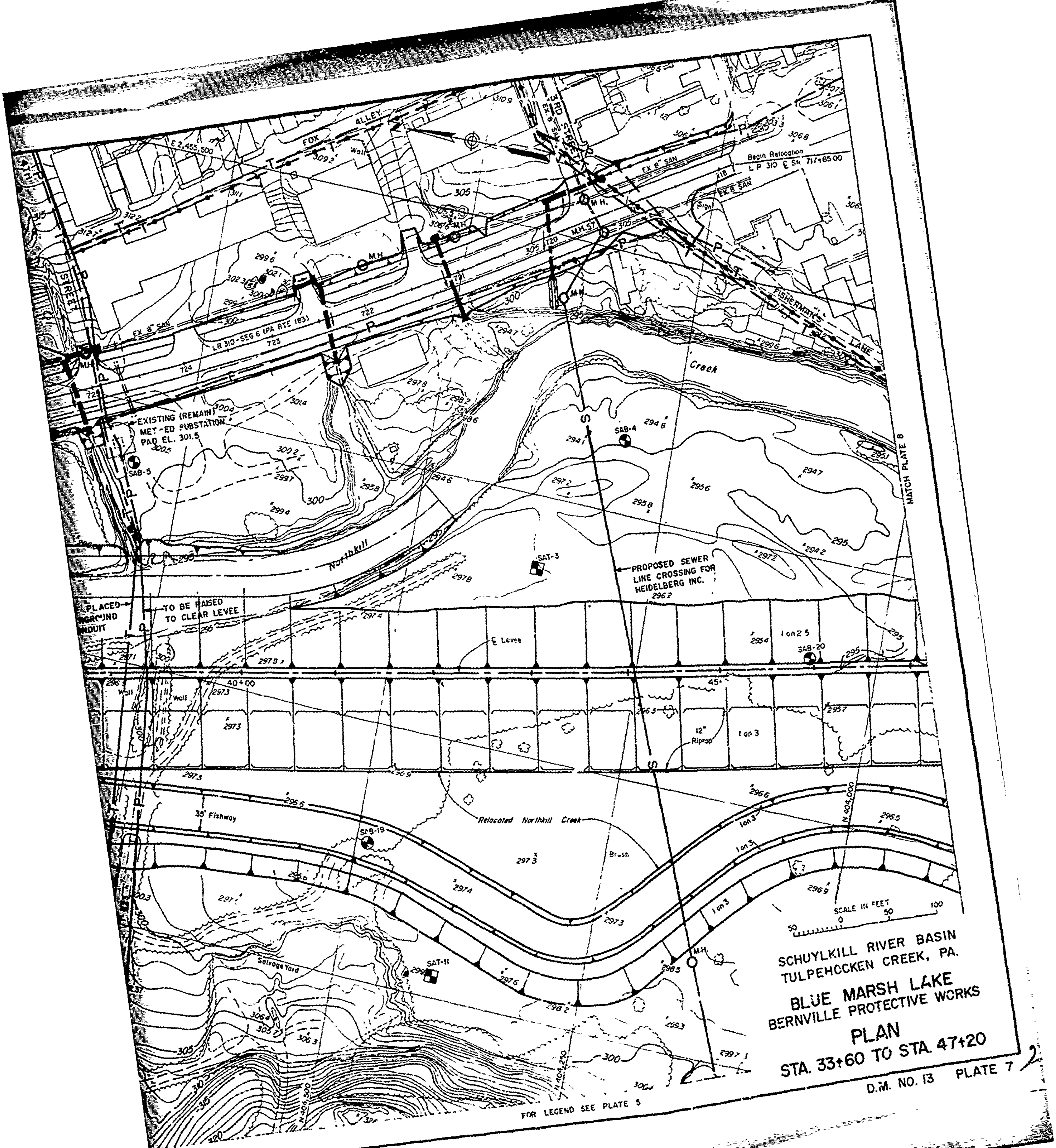
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

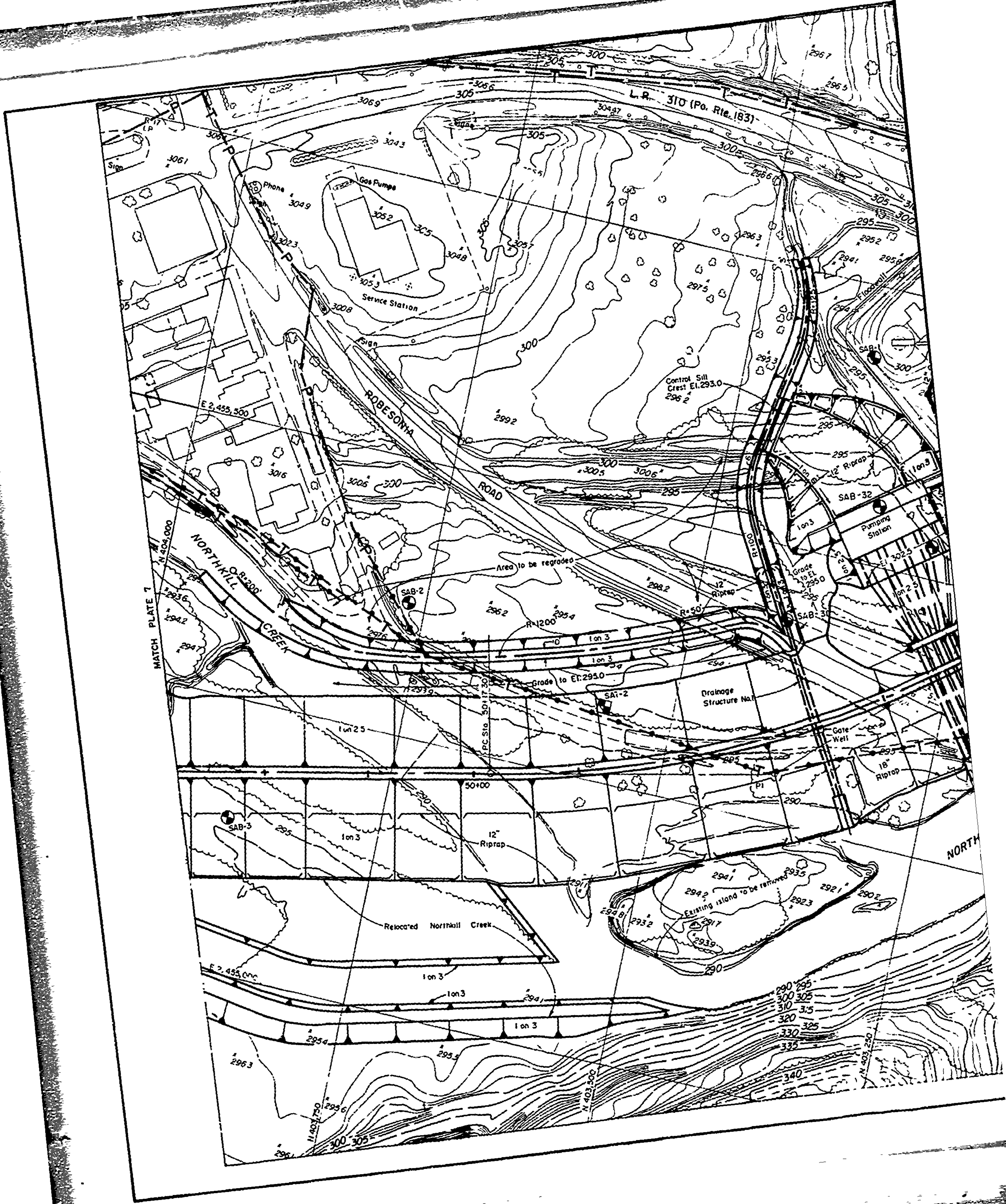
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

PLAN
STA. 19+80 TO STA. 33+60

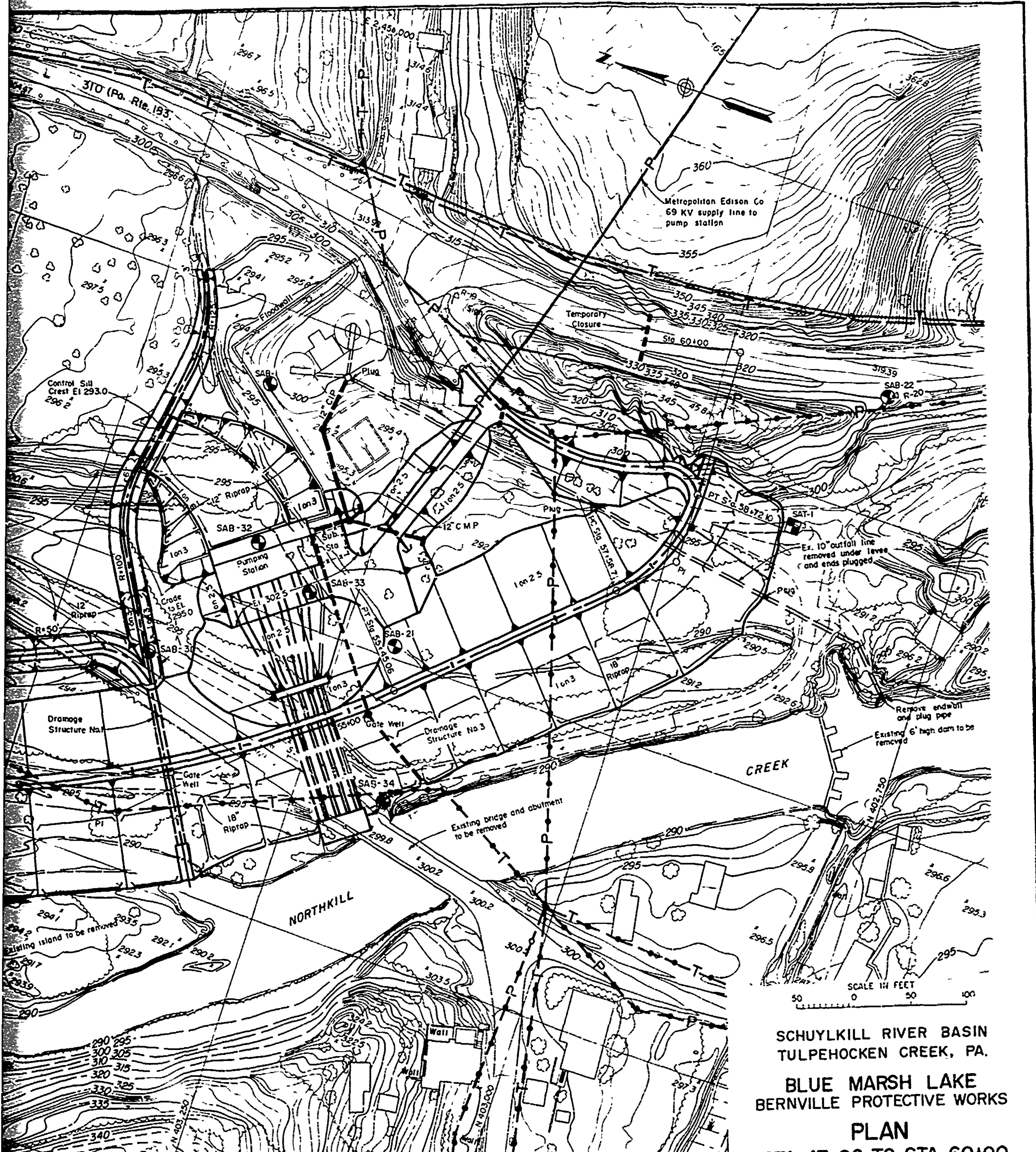


MATCH PLATE 6


SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
PLAN
STA. 33+60 TO STA. 47+20
D.M. NO. 13
PLATE 7
FOR LEGEND SEE PLATE 5
MATCH PLATE 8
SCALE IN FEET
50 0 50 100
FOX ALLEY
3RD STREET
FISHERMAN'S LANE
STREET
Begin Relocation
LR 310-SEG 6 (PA RTE 183)
EX 8" SAN
EXISTING (REMAIN)
MET-ED SUBSTATION
PAD EL. 301.5
PROPOSED SEWER
LINE CROSSING FOR
HEIDELBERG INC.
TO BE RAISED
TO CLEAR LEVEE
Northkill
Creek
℄ Levee
1 on 2.5
1 on 3
12" Riprap
35' Fishway
Relocated Northkill Creek
Brush
Salvage Yard
SAB-4
SAB-5
SAT-3
SAB-20
SAB-19
SAT-11
40+00
45+



L.R. 310 (Pa. Rte. 183)
Phone
Gas Pumps
Service Station
Sign
ROBESONIA ROAD
NORTHKILL CREEK
MATCH PLATE 7
Control Sill Crest El. 293.0
Area to be regraded
Floodwall
SAB-32
Pumping Station
12" Riprap
18" Riprap
SAB-2
SAB-3
SAI-2
Grade to El. 295.0
Drainage Structure No.1
Gate Well
1 on 3
1 on 2.5
Relocated Northkill Creek
Existing island to be removed
NORTH



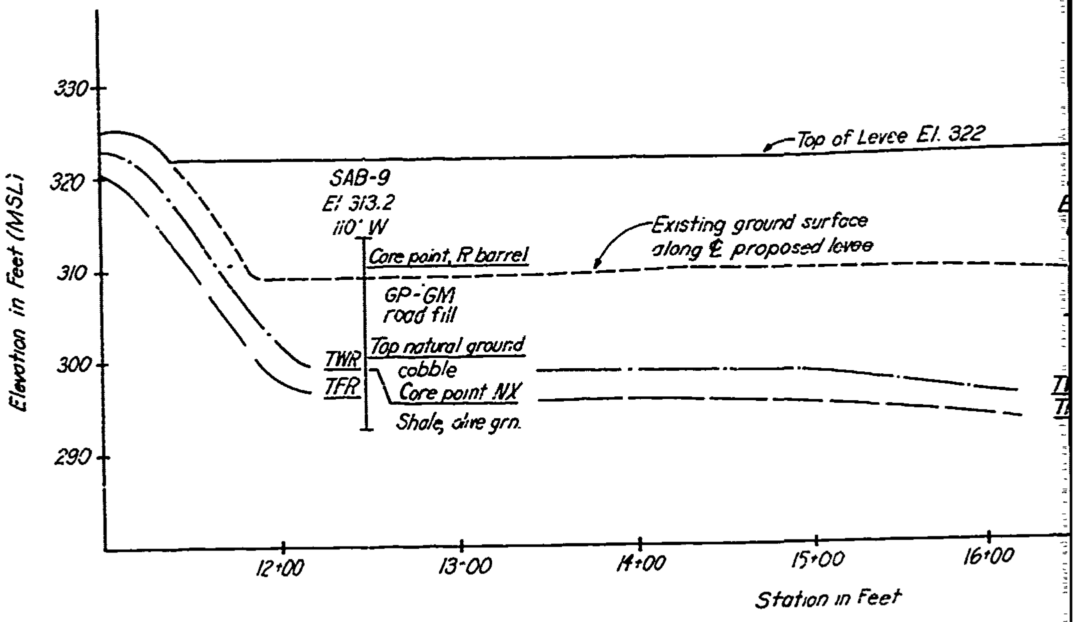
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

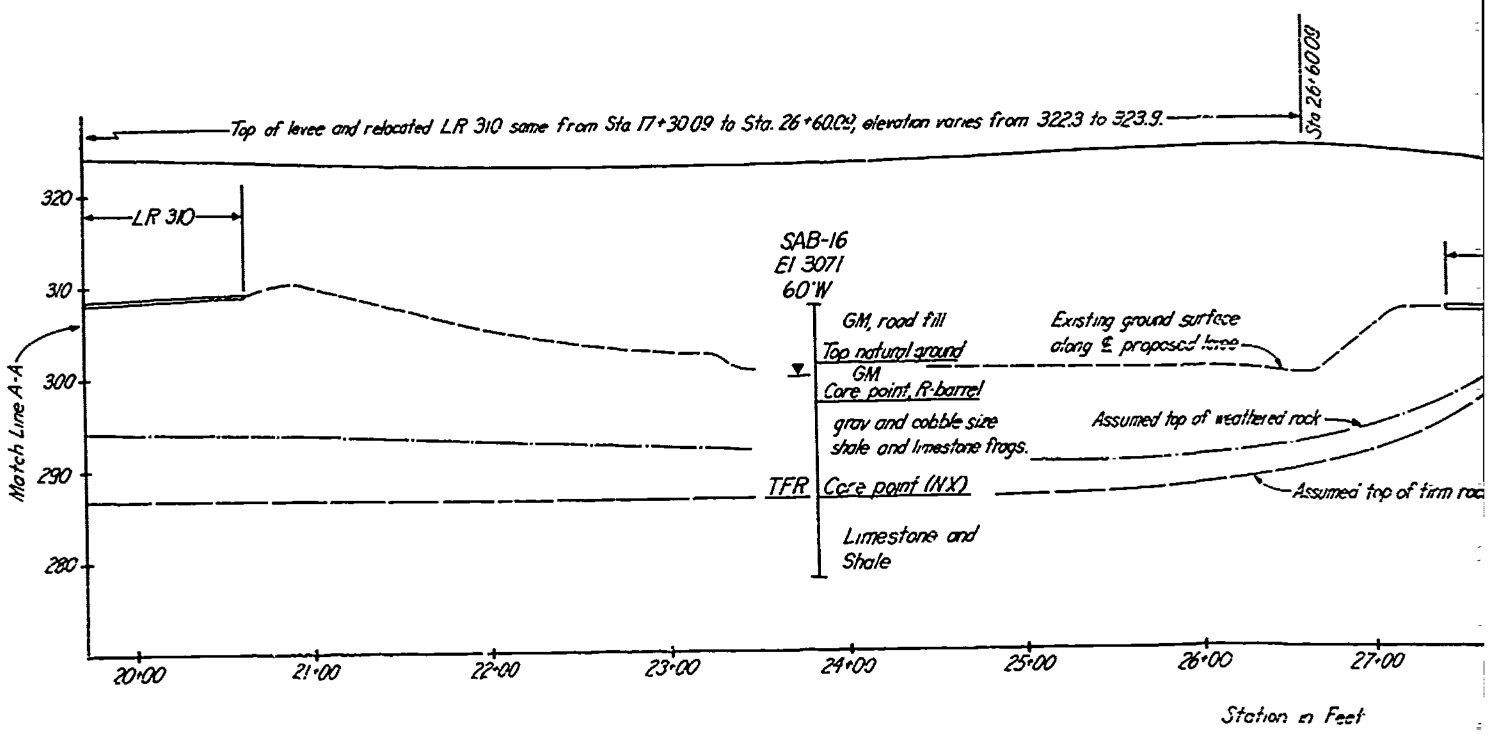
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

PLAN
STA. 47+20 TO STA. 60+00

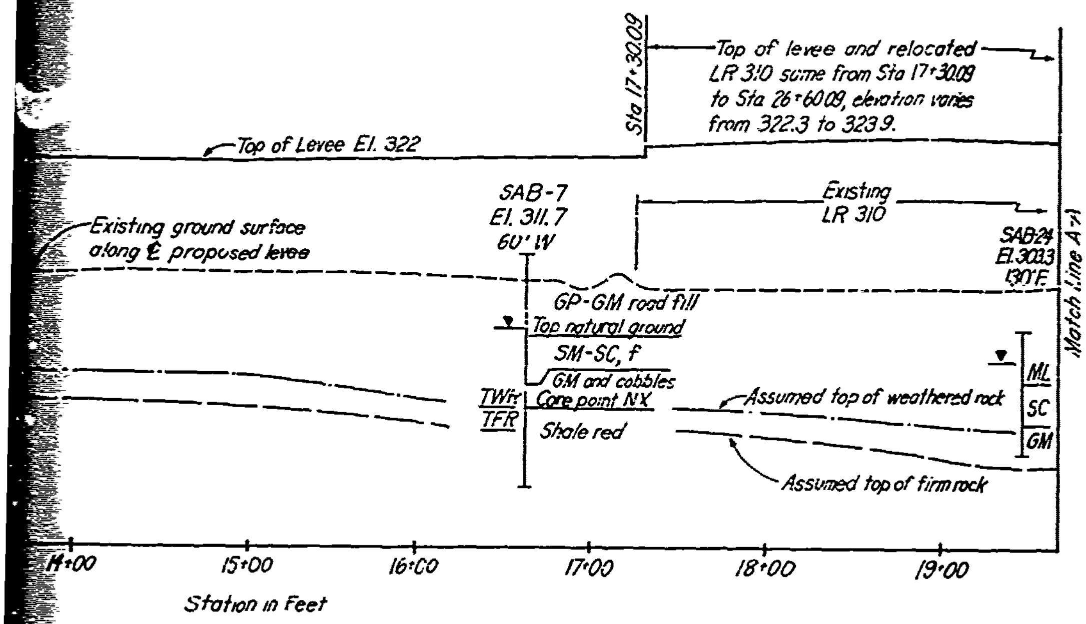
FOR LEGEND SEE PLATE 5

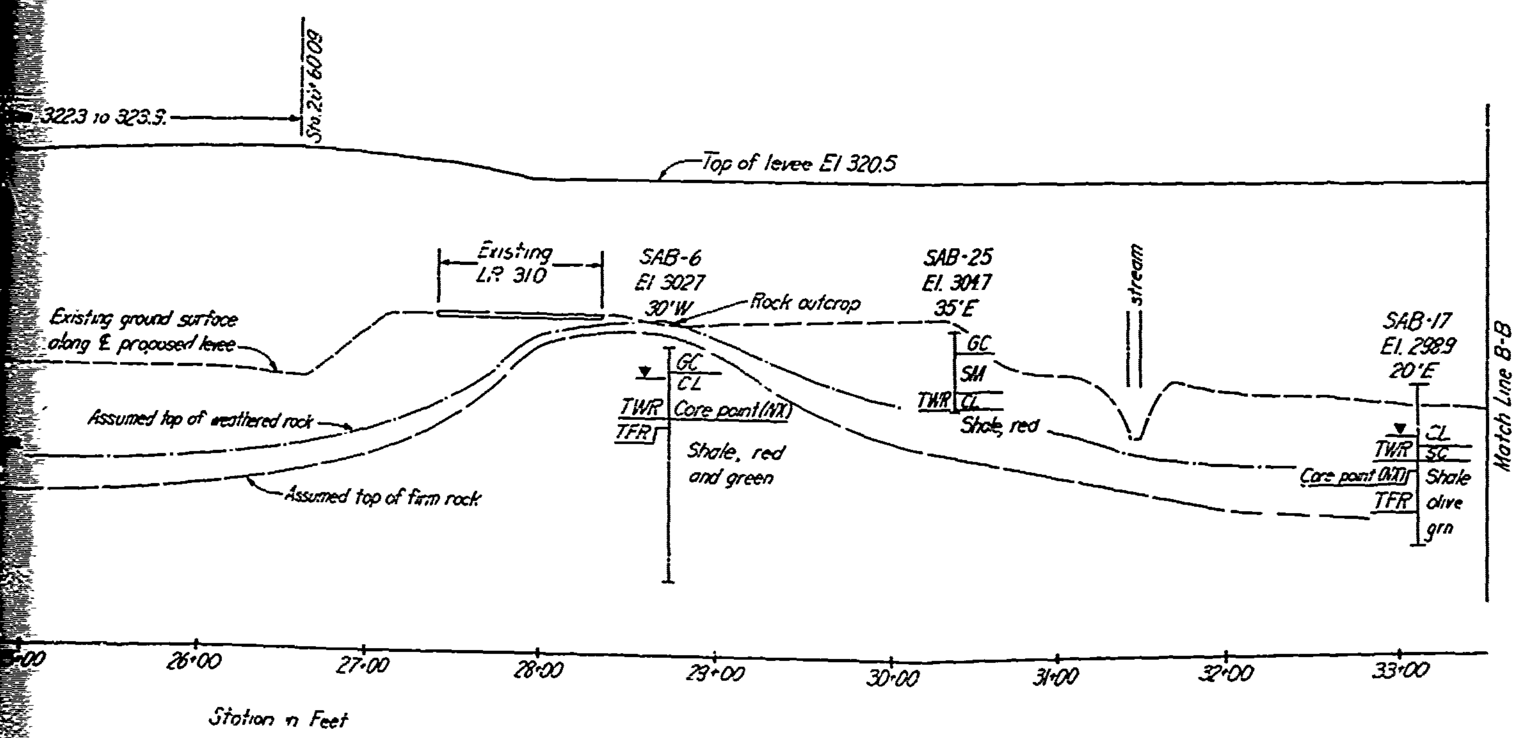
D.M. NO. 13 PLATE 8





Notes: 1. Levee shown in plan on sheets 5 to
2. Boring logs shown on sheets P 1 to

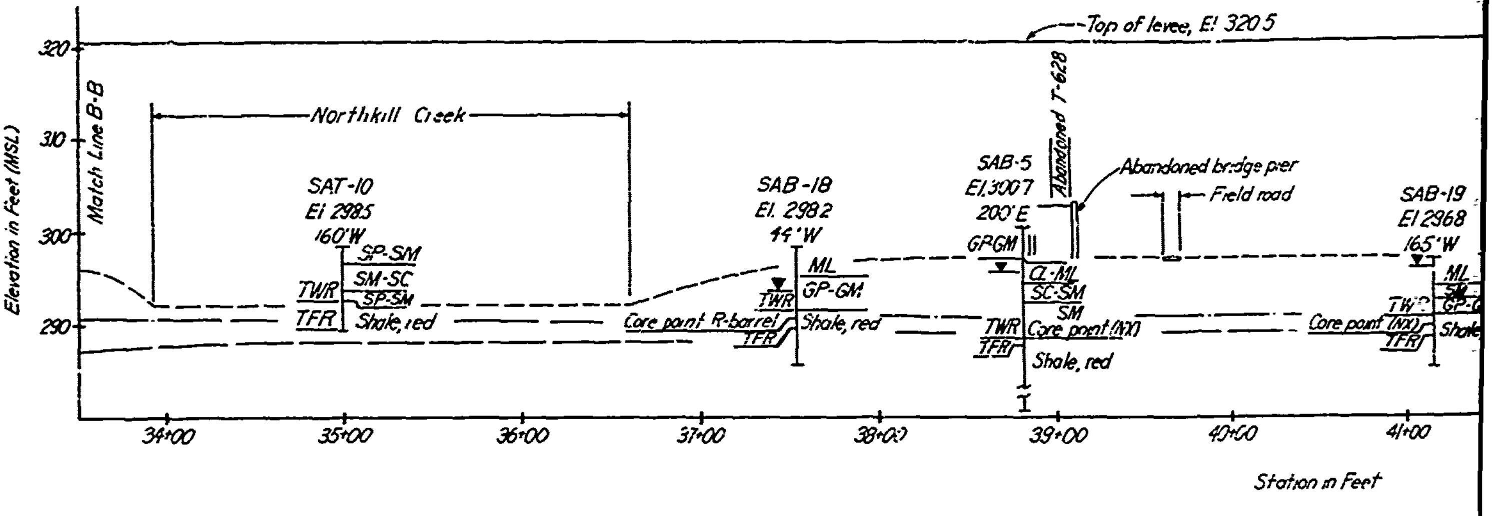


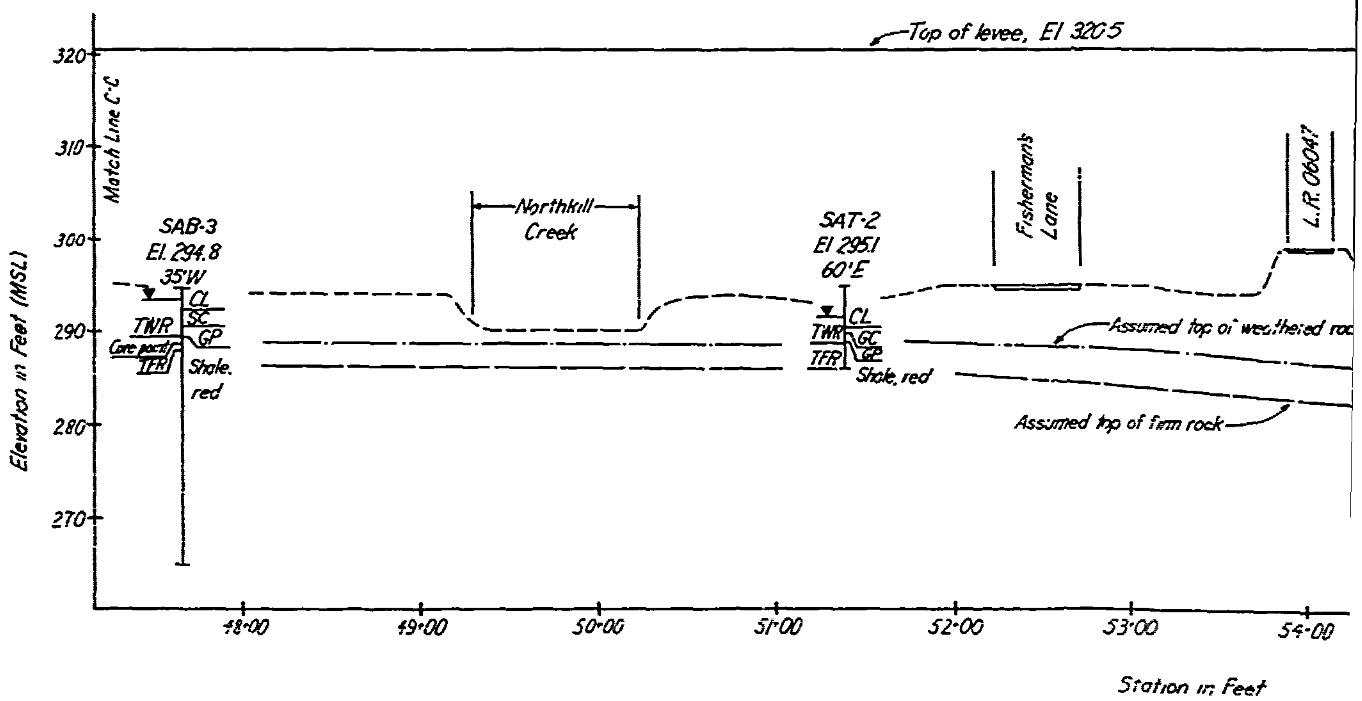


Notes: 1 Levee shown in plan on sheets 5 to 8
2. Boring logs shown on sheets A-1 to A-4

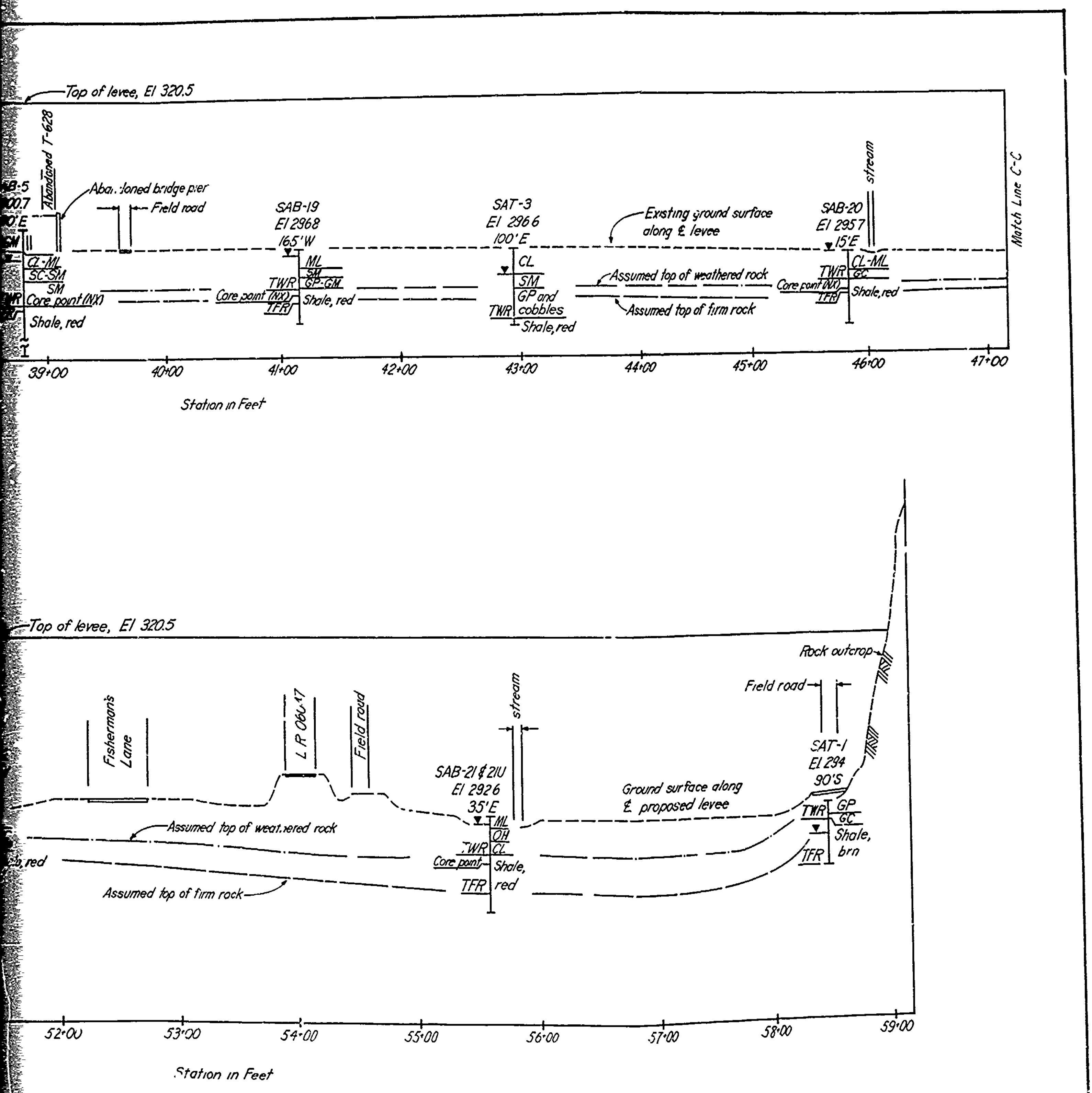
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
PROFILE ℄ LEVEE
STA. 11+00 TO STA. 33+50

D. M. NO. 13 PLATE 9





Notes: 1 Levee shown in plan on s
2 Boring logs shown on shee



Notes: 1 Levee shown in plan on sheets 5 to 8
2 Boring logs shown on sheets A-1 to A-4

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

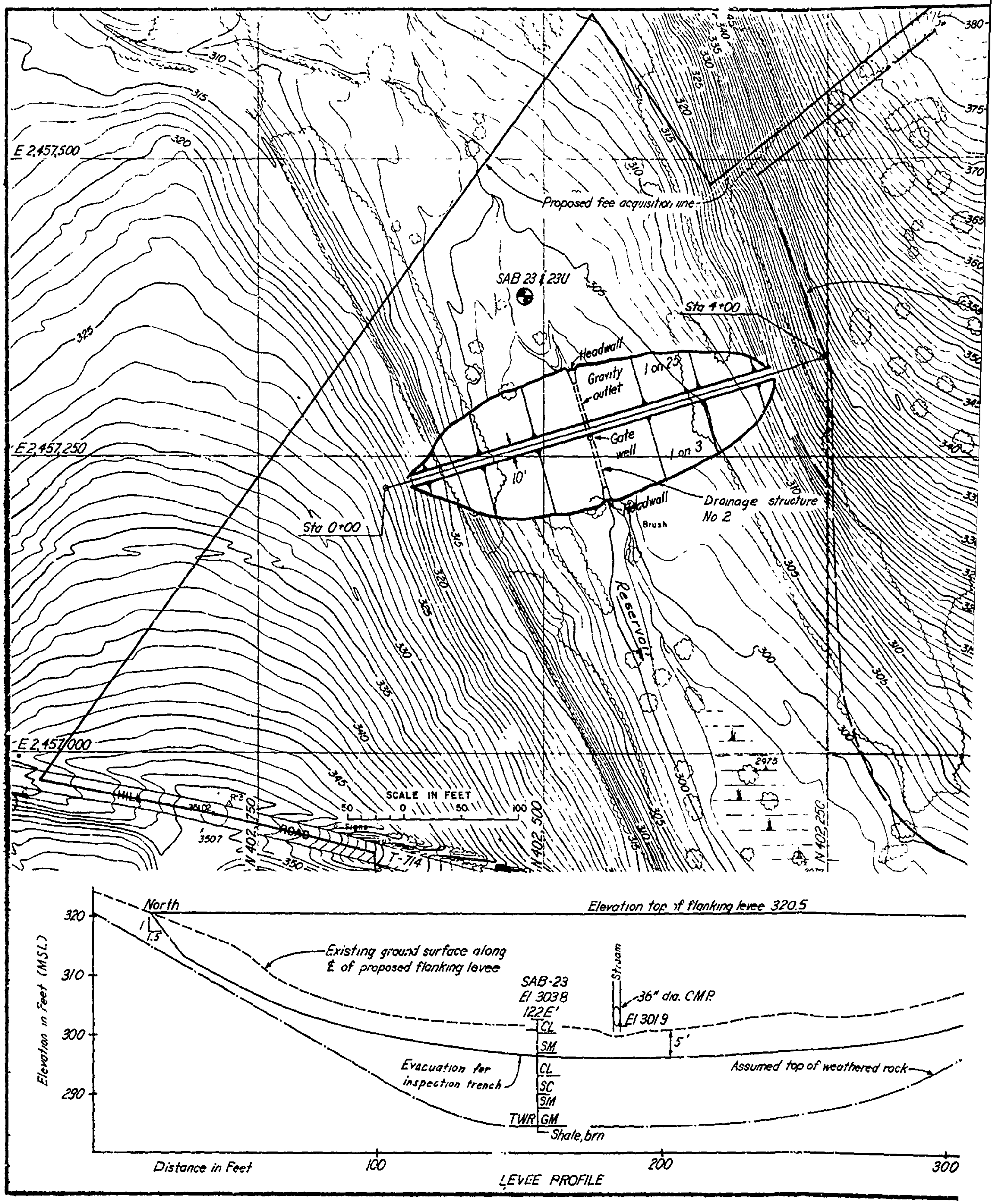
BLUE MARSH LAKE

BERNVILLE PROTECTIVE WORKS

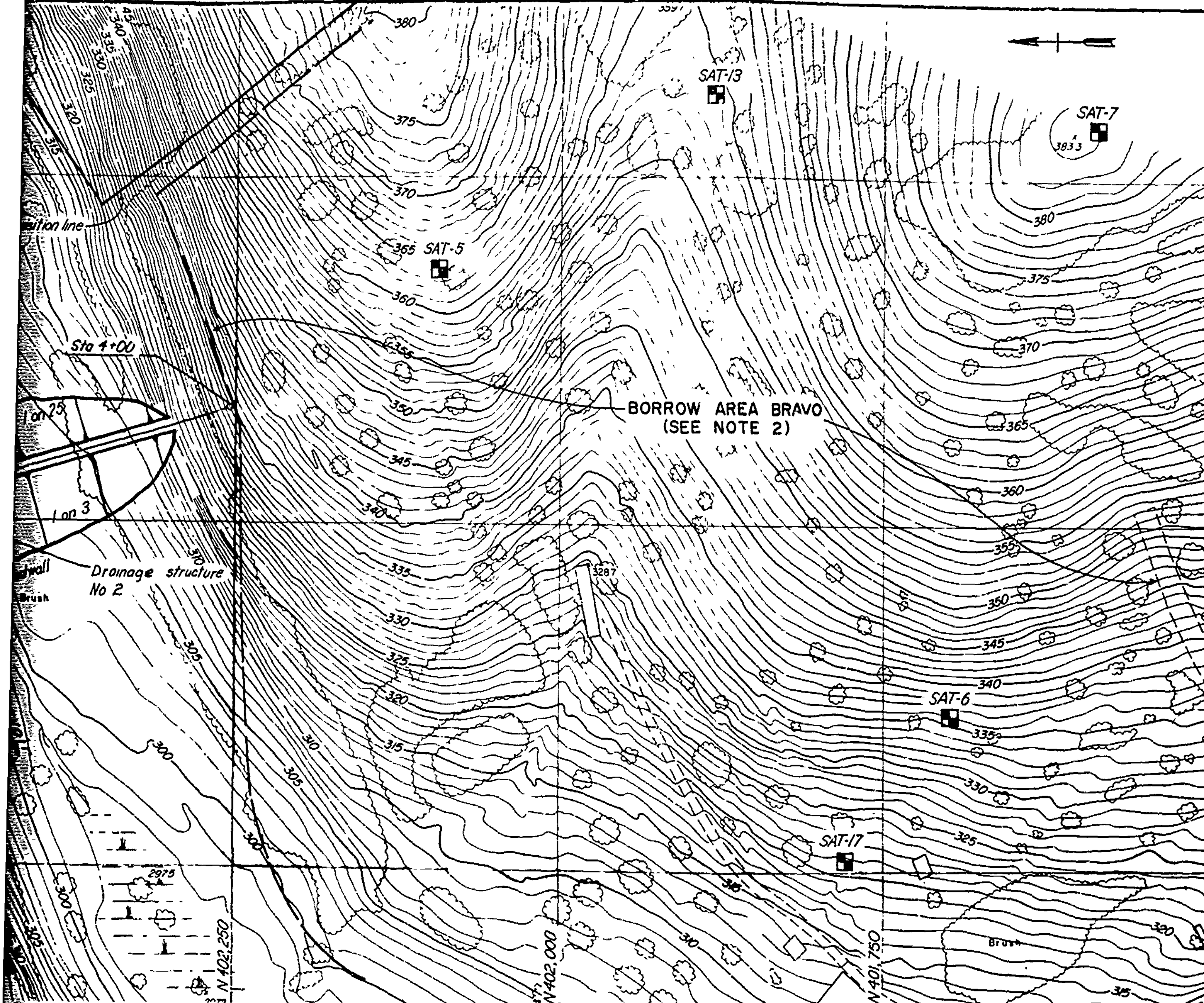
PROFILE ℄ LEVEE

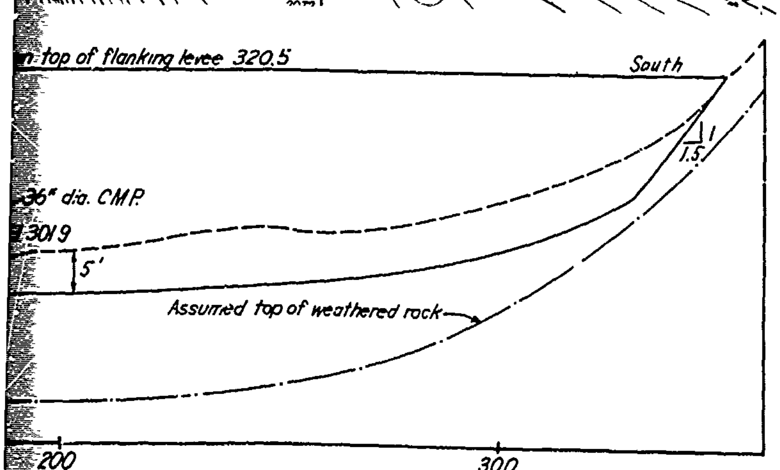
STA. 33+50 TO STA. 59+00

D.M. NO. 13 PLATE 10



E 2,457,500
E 2,457,250
E 2,457,000
Proposed fee acquisition line
SAB 23 & 23U
Sta 4+00
Headwall
Gravity outlet
1 on 2.5
Gate well
1 on 3
10'
Sta 0+00
Headwall
Brush
Drainage structure No 2
Reservoir
SCALE IN FEET
50 0 50 100
HILL
ROAD
T-714
N 402,750
N 402,500
N 402,250
North
Elevation top of flanking levee 320.5
Existing ground surface along ℄ of proposed flanking levee
SAB-23
El 303.8
122E'
CL
SM
CL
SC
SM
GM
TWR
Shale, brn
Stream
36" dia. CMP
El 301.9
5'
Evacuation for inspection trench
Assumed top of weathered rock
Elevation in Feet (MSL)
Distance in Feet
LEVEE PROFILE





Notes: 1 Boring logs shown on plates A-2 and A-4

2 Limits of borrow area Bravo and position of flanking levee with respect to protective works levee shown on plate 3

3 Refer to plate 13 for flanking levee section

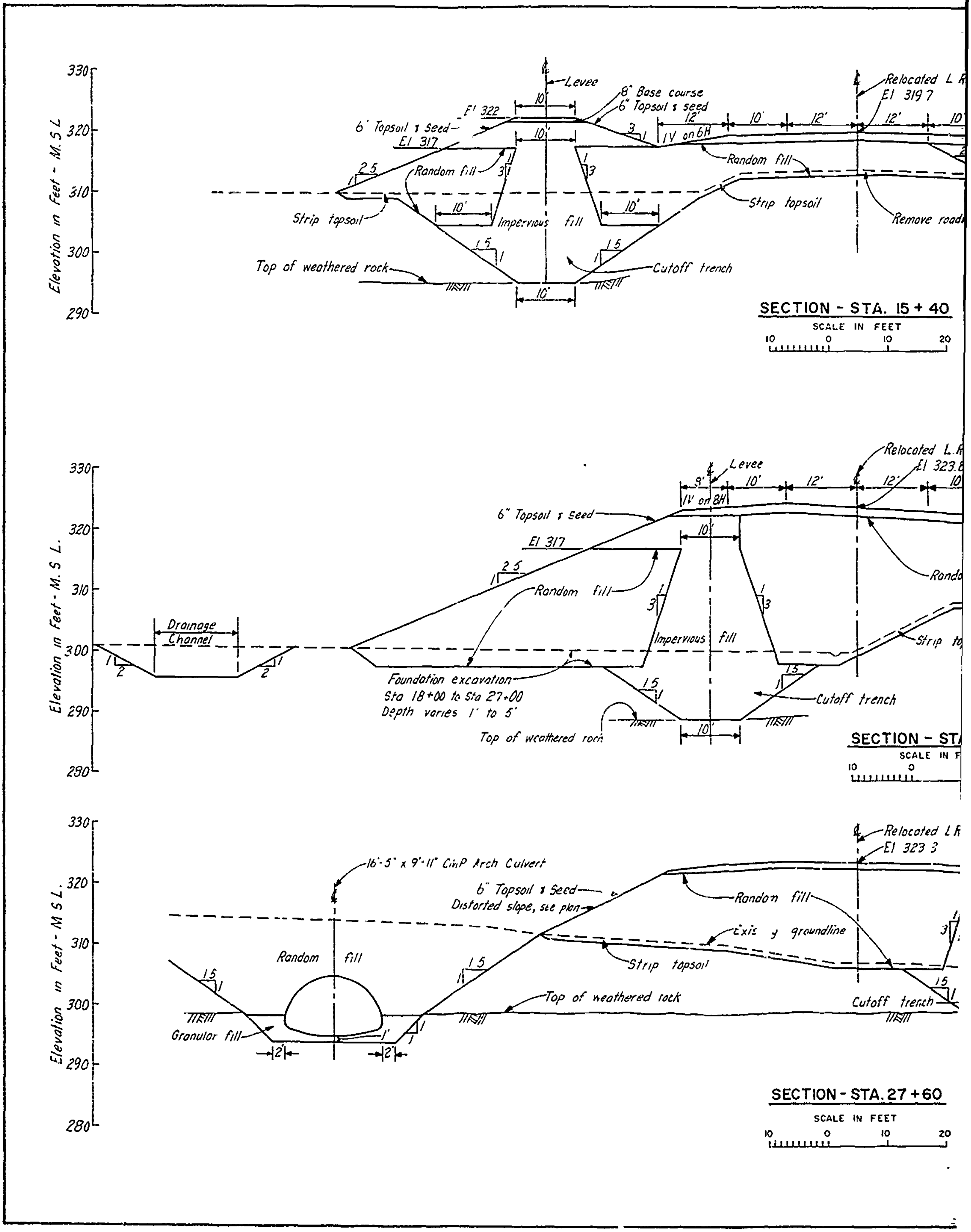
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

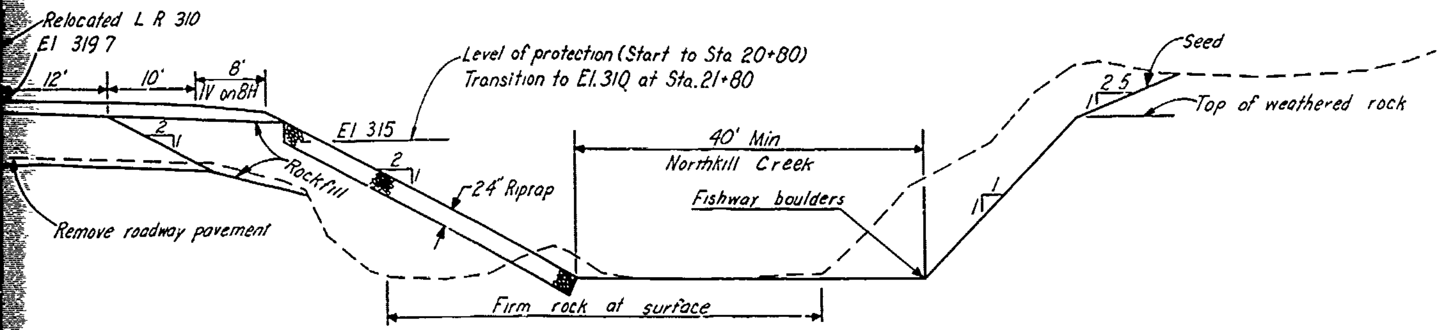
BLUE MARSH LAKE

BERNVILLE PROTECTIVE WORKS

FLANKING LEVEE
PLAN & PROFILE

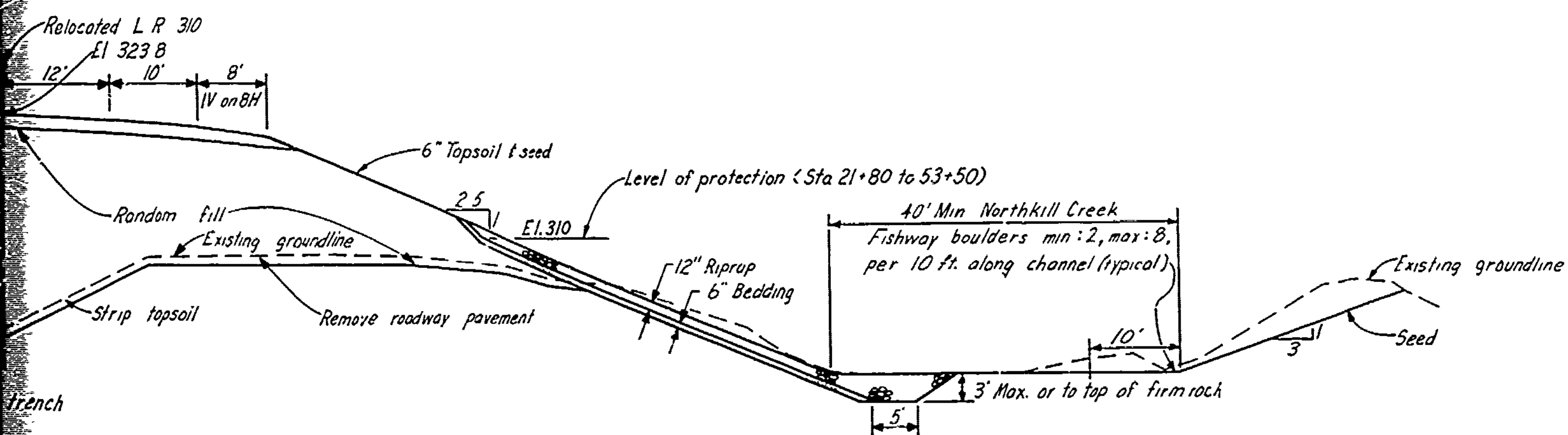
D.M. NO. 13 PLATE 11


Elevation in Feet - M.S.L.
Levee
8" Base course
6" Topsoil & seed
Relocated L.R.
El 319.7
El 322
6" Topsoil & Seed
El 317
1V on 6H
Random fill
Strip topsoil
Impervious fill
Remove road
Top of weathered rock
Cutoff trench
SECTION - STA. 15 + 40
SCALE IN FEET
Levee
Relocated L.R.
1V on 8H
6" Topsoil & Seed
El 317
Random fill
Drainage Channel
Impervious fill
Foundation excavation
Sta 18+00 to Sta 27+00
Depth varies 1' to 5'
Top of weathered rock
Cutoff trench
Strip topsoil
SECTION - STA
SCALE IN FEET
Relocated L.R.
El 323.3
16'-5" x 9'-11" C.i.P. Arch Culvert
6" Topsoil & Seed
Distorted slope, see plan
Random fill
Existing groundline
Strip topsoil
Top of weathered rock
Granular fill
Cutoff trench
SECTION - STA. 27 + 60
SCALE IN FEET



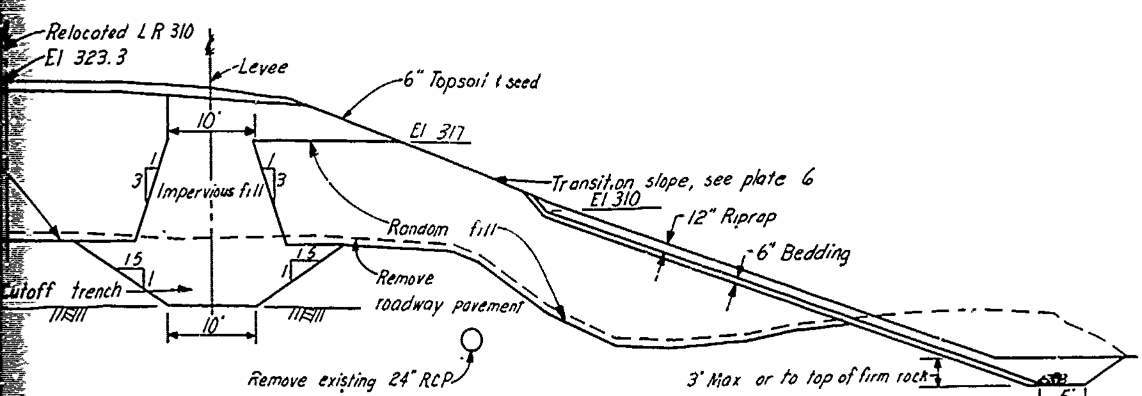
TA. 15 + 40

FEET
10 20



EC. ON - STA. 25+30

SCALE IN FEET
0 10 20



STA. 27 +60

FEET
10 20

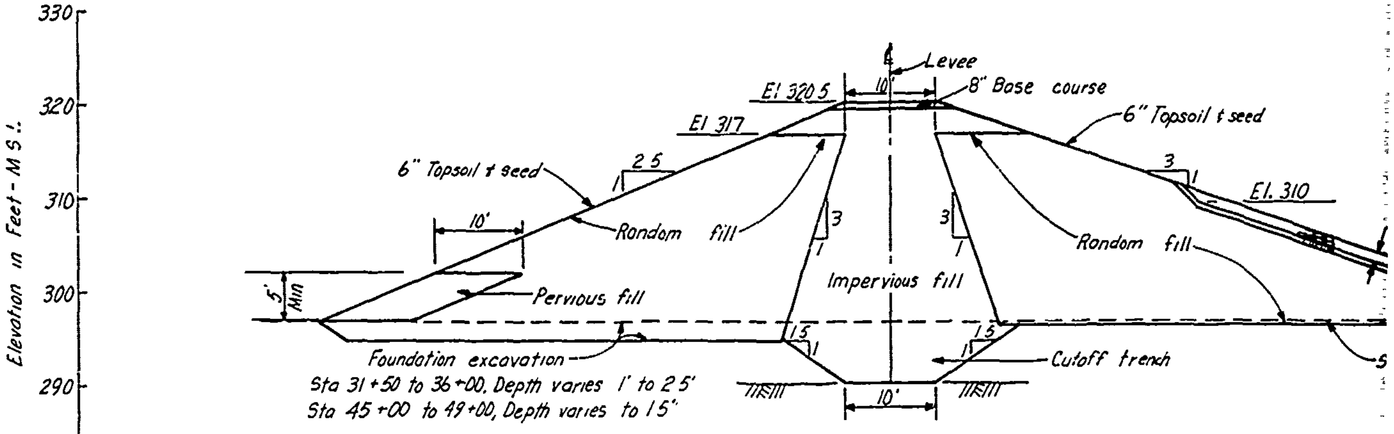
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE

BERNVILLE PROTECTIVE WORKS

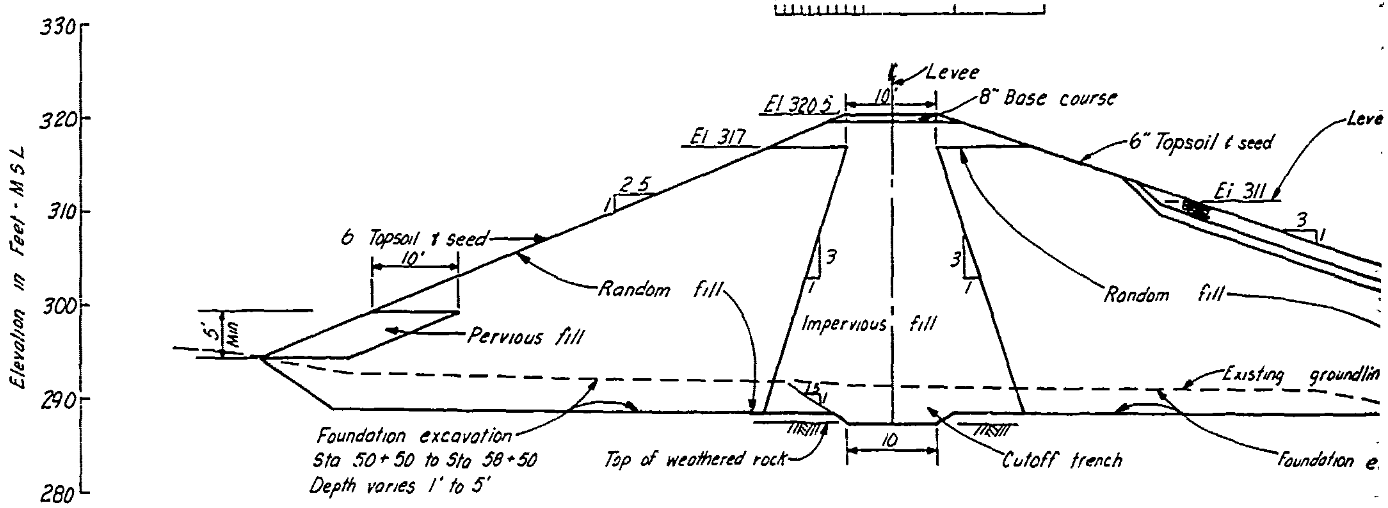
TYPICAL SECTIONS
LEVEE AND CREEK RELOCATION

D.M. NO. 13 PLAT



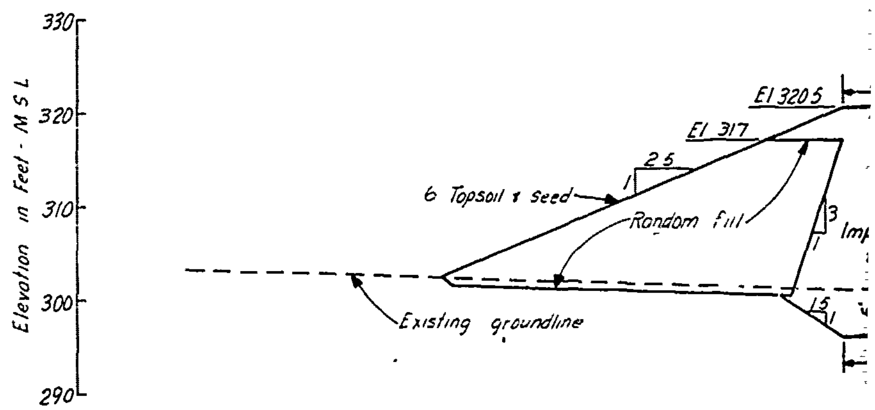
TYPICAL SECTION - STA. 29+35 to 53+30

SCALE IN FEET
10 0 10 20



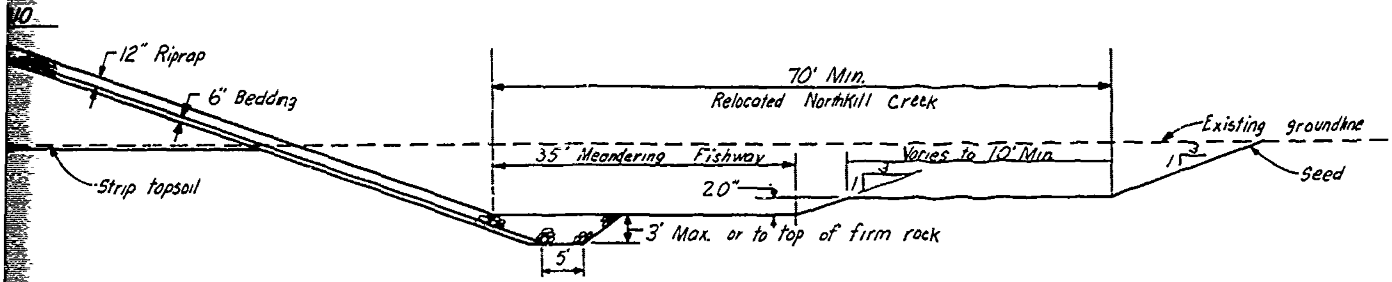
TYPICAL SECTION - STA. 56+35 to 58+90

SCALE IN FEET
10 0 10 20

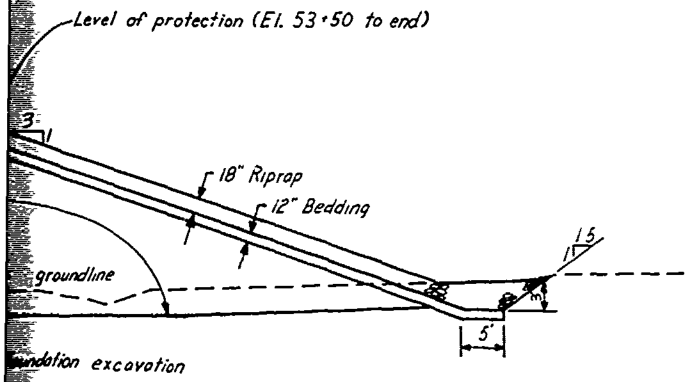


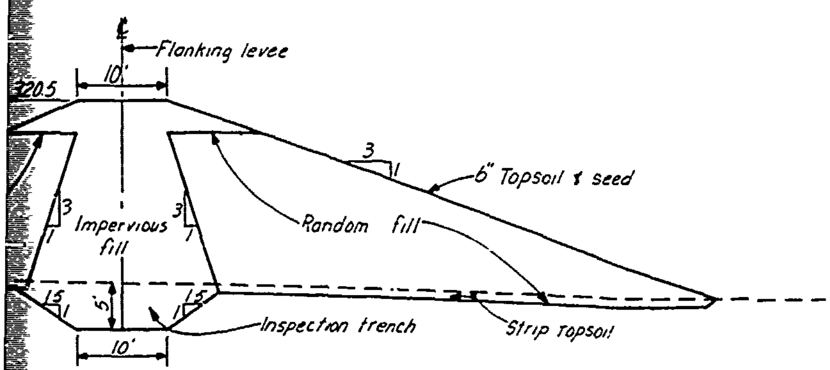
TYPICAL SECTION

SCAL
10 0



See plates 21 and 24 for sections at pumping station and gravity outfall in area between stations 53+30 to 56+35.





ECTION - FLANKING LEVEE

SCALE IN FEET

0 10 20

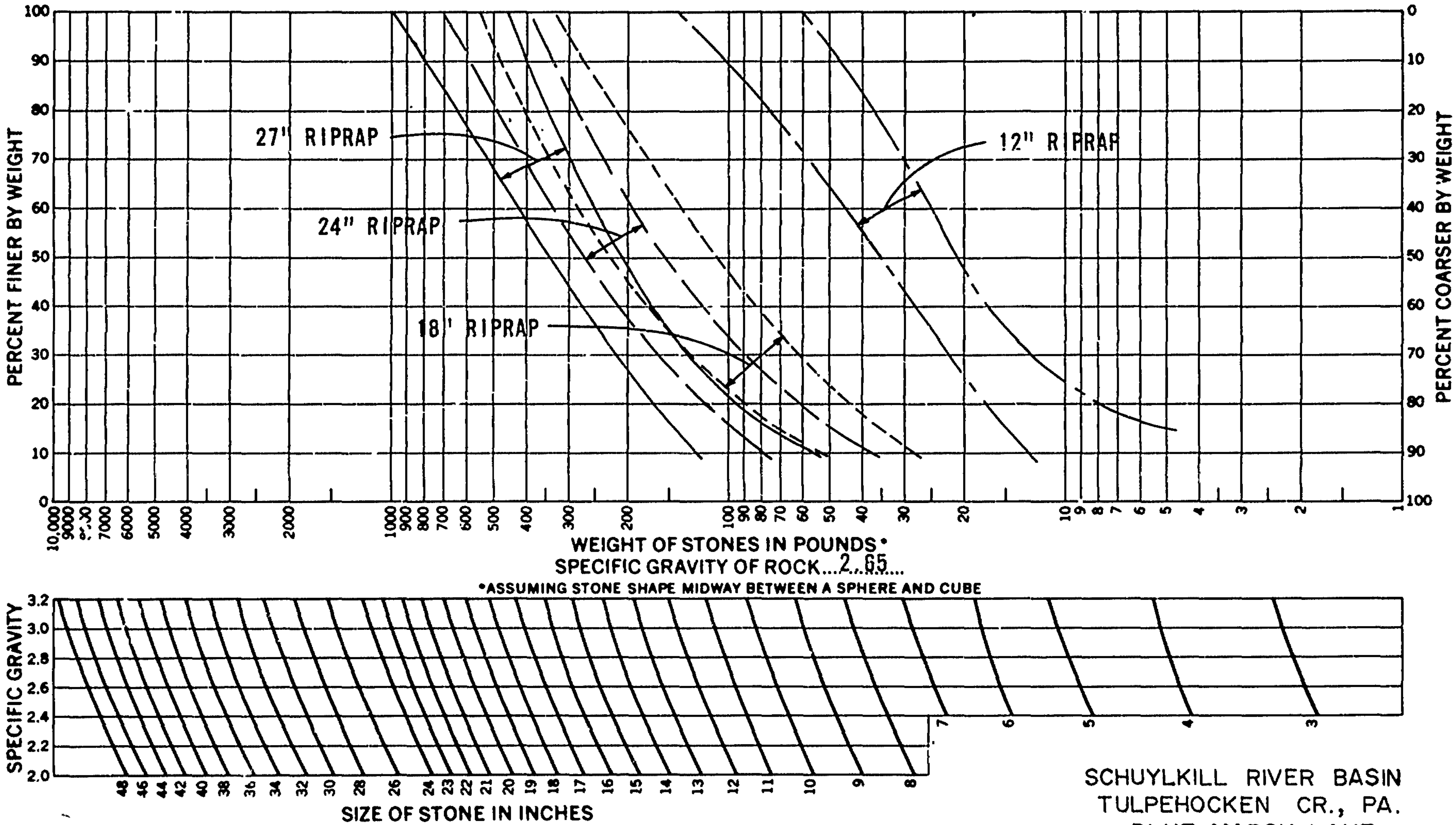
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE

BERNVILLE PROTECTIVE WORKS

TYPICAL SECTIONS
LEVEE, CREEK RELOCATION
AND FLANKING LEVEE

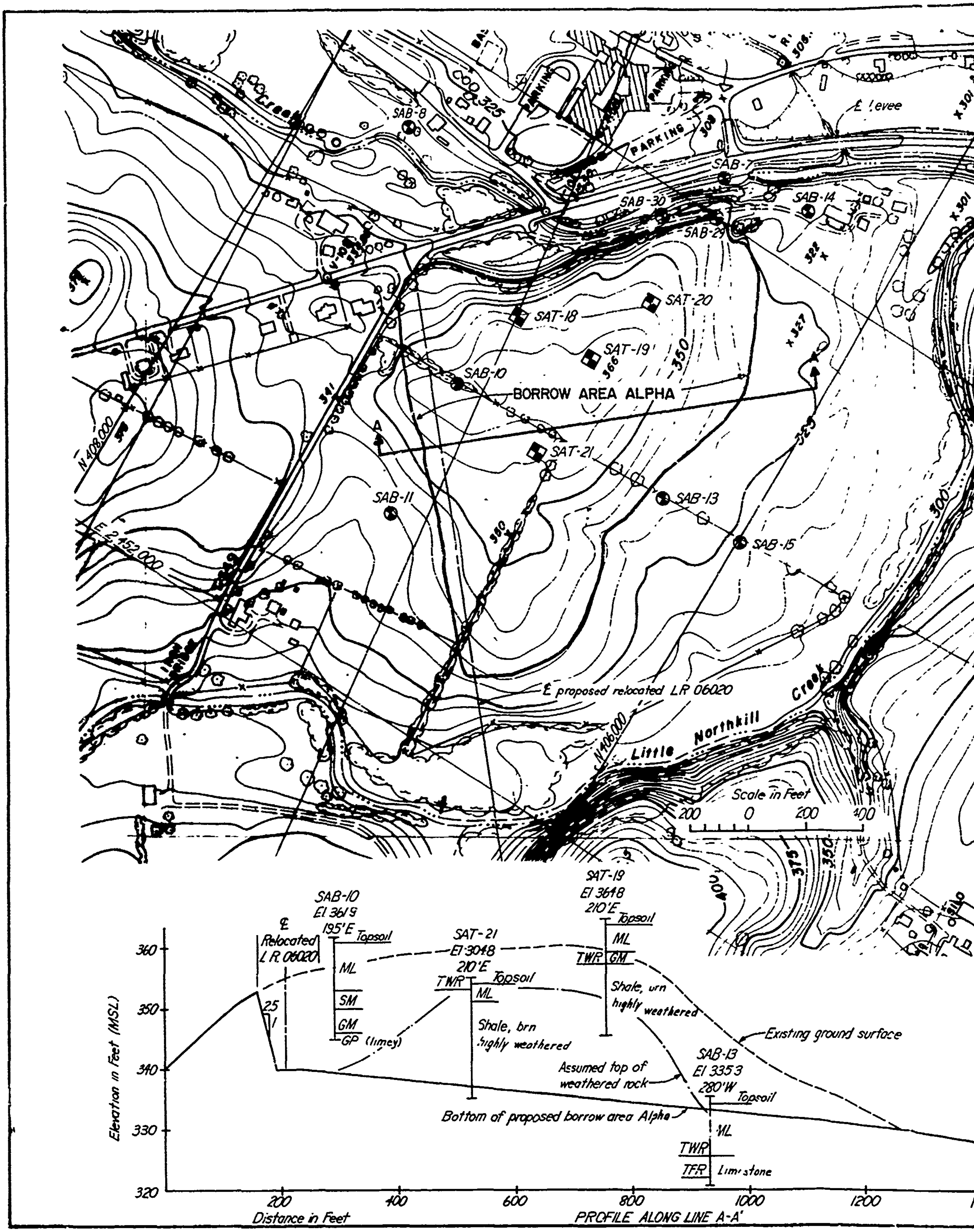
D.M. NO. 13 PLATE 13



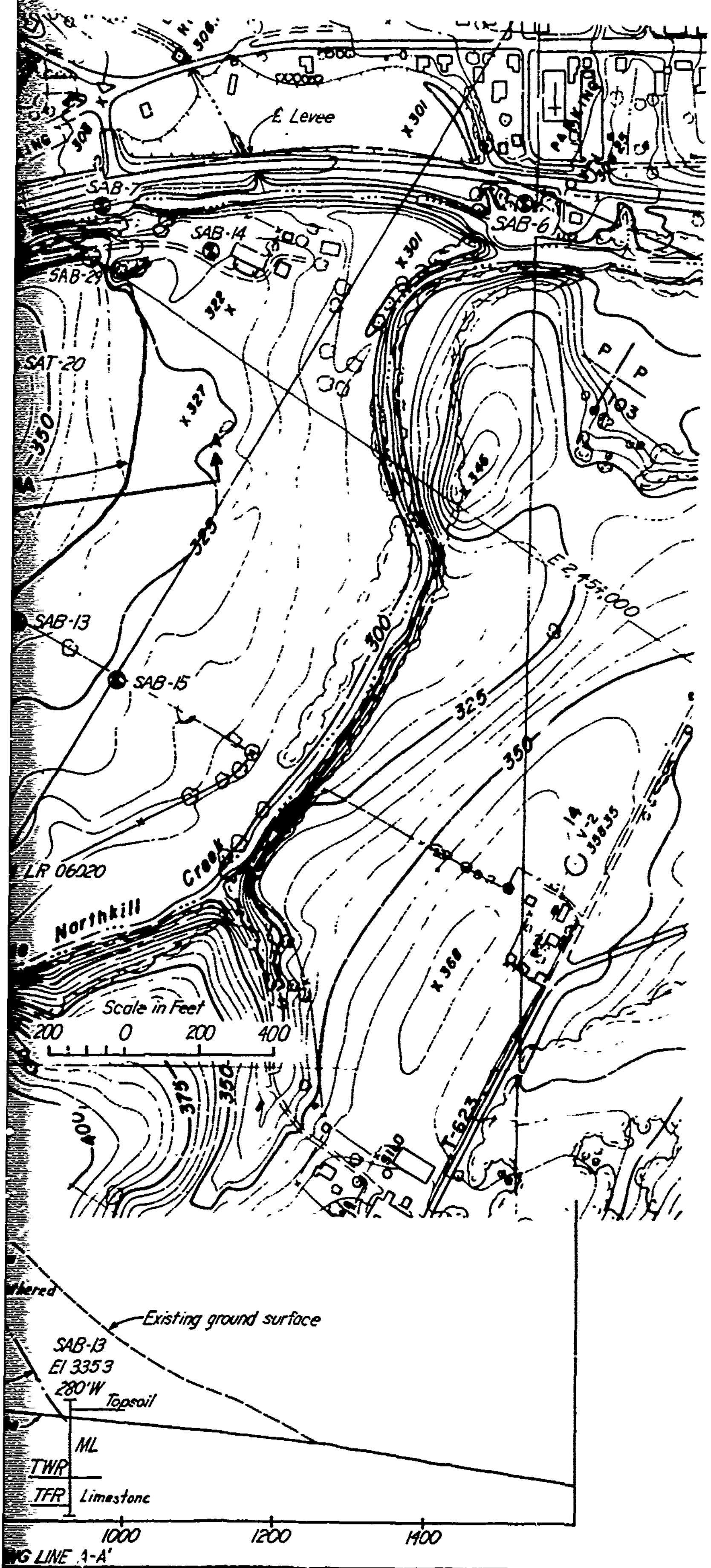
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CR., PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

RIPRAP GRADUATION CURVES

ENG FORM 4055
APR 67



SAB-8
PARKING
℄ Levee
SAB-7
SAB-30
SAB-14
SAB-29
SAT-18
SAT-20
SAT-19
SAB-10
BORROW AREA ALPHA
A
SAT-21
SAB-13
SAB-11
SAB-15
N 408,000
E 2,452,000
℄ proposed relocated LR 06020
N 406,000
Little Northkill Creek
Scale in Feet
200 0 200 400
SAB-10
El 361.9
195'E
Topsoil
ML
SM
GM
GP (limey)
℄ Relocated L.R. 06020
25
1
SAT-21
El 304.8
210'E
TWR
Topsoil
ML
Shale, brn highly weathered
SAT-19
El 364.8
210'E
Topsoil
ML
TWR
GM
Shale, brn highly weathered
Existing ground surface
Assumed top of weathered rock
SAB-13
El 335.3
280'W
Topsoil
ML
TWR
TFR
Limestone
Bottom of proposed borrow area Alpha
Elevation in Feet (MSL)
360
350
340
330
320
200
400
600
800
1000
1200
Distance in Feet
PROFILE ALONG LINE A-A'



Notes: 1. Boring logs shown on plates A-1 thru A-4

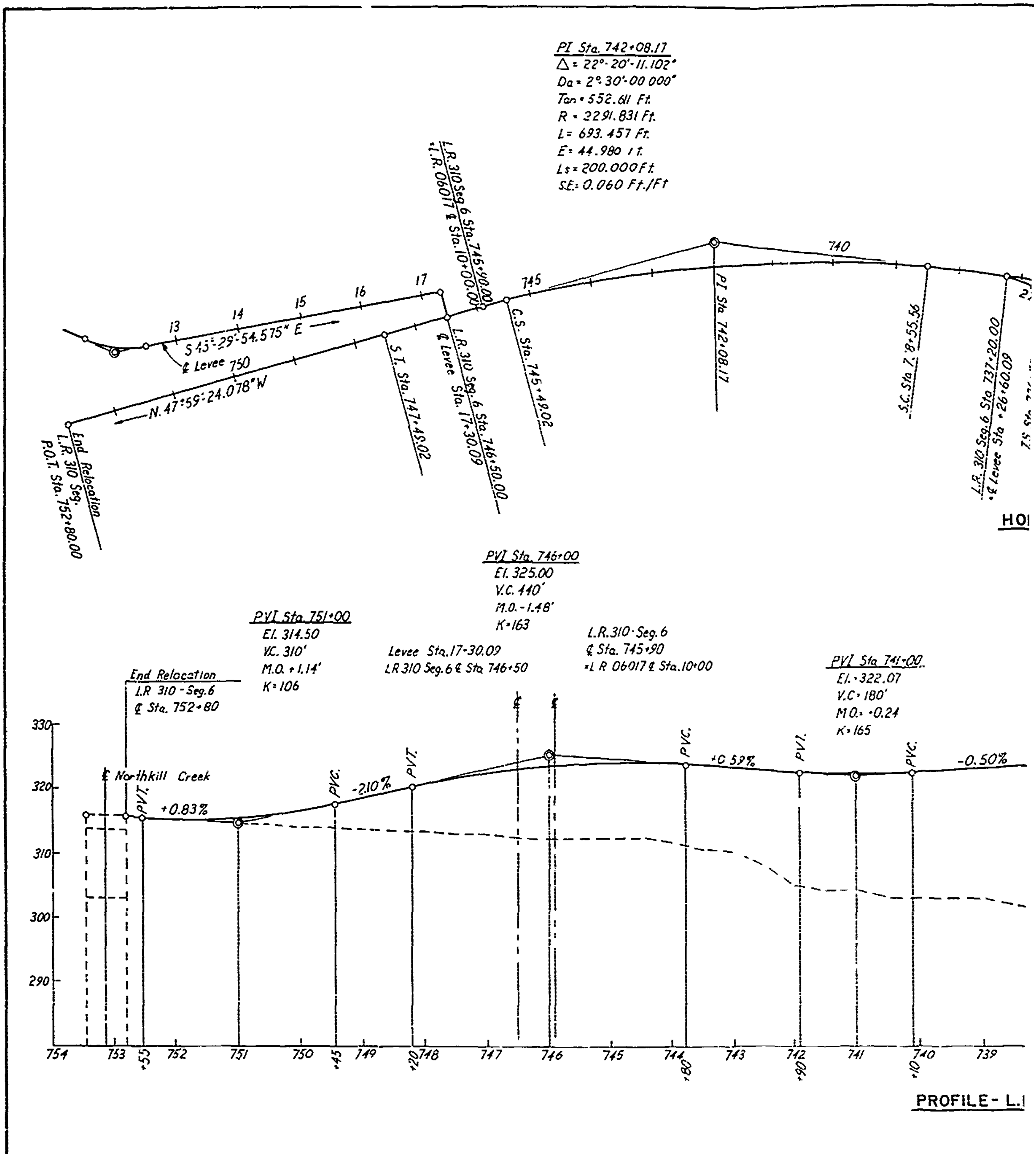
2. Location of borrow area Alpha with respect to the protective works levee shown on plate 3

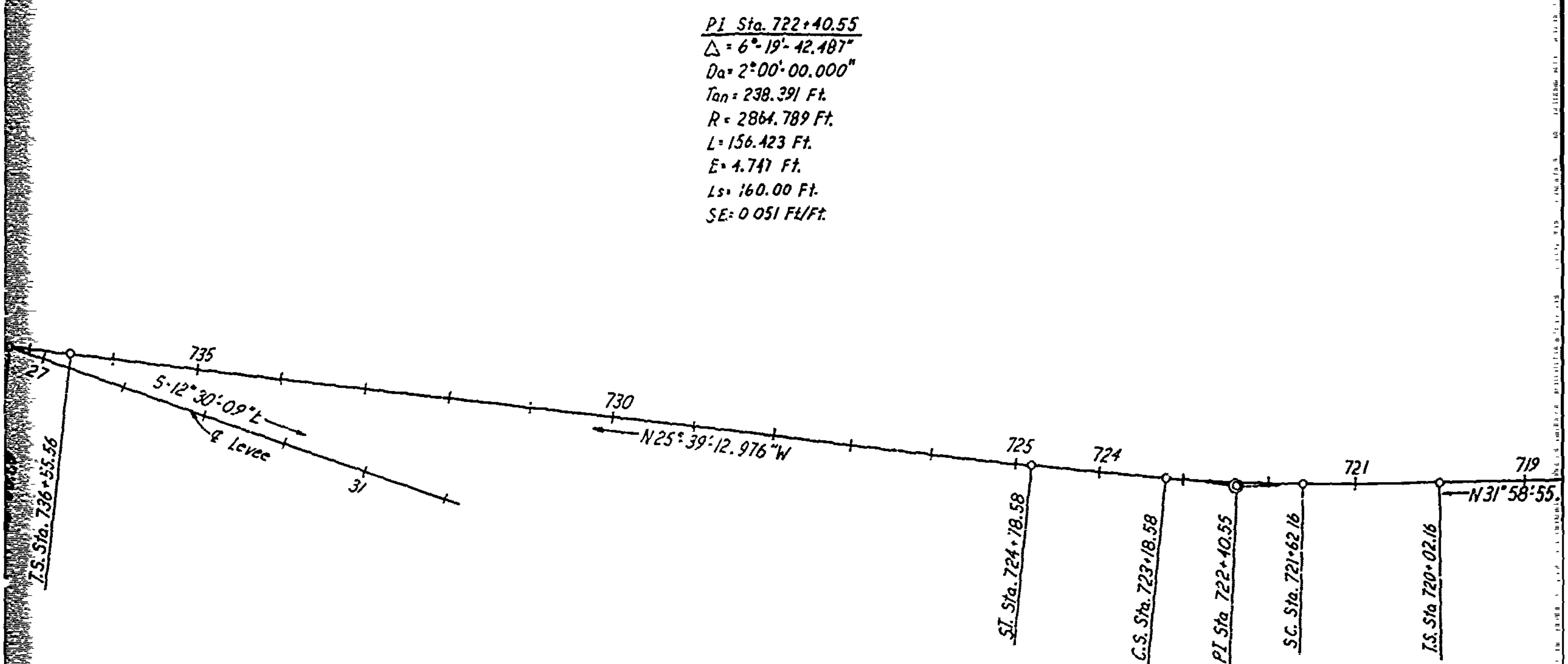
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE

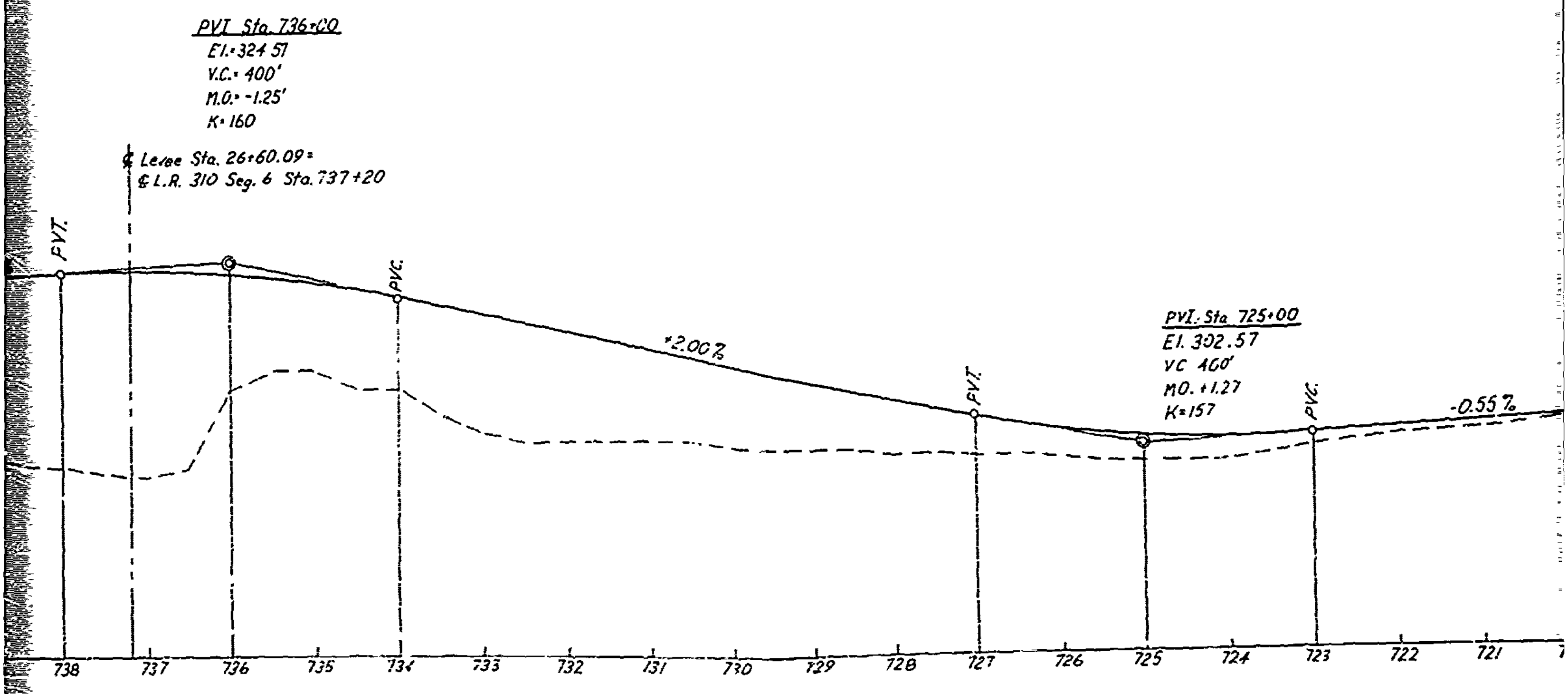
BERNVILLE PROTECTIVE WORKS

BORROW AREA ALPHA
PLAN & PROFILE


PI Sta. 742+08.17
Δ = 22°-20'-11.102"
Da = 2°-30'-00.000"
Tan = 552.611 Ft.
R = 2291.831 Ft.
L = 693.457 Ft.
E = 44.980 Ft.
Ls = 200.000 Ft.
S.E. = 0.060 Ft./Ft.
L.R. 310 Seg. 6 Sta. 745+90.00
= L.R. 06017 ℄ Sta. 10+00.00
740
745
17
16
15
14
13
S 43°-29'-54.575" E
℄ Levee
750
N. 47°-59'-24.078" W
End Relocation
L.R. 310 Seg.
P.O.T. Sta. 752+80.00
S.T. Sta. 747+45.02
L.R. 310 Seg. 6 Sta. 746+50.00
℄ Levee Sta. 17+30.09
C.S. Sta. 745+49.02
PI Sta. 742+08.17
S.C. Sta. 738+55.56
L.R. 310 Seg. 6 Sta. 737+20.00
= ℄ Levee Sta. +28+60.09
HOI
PVI Sta. 746+00
El. 325.00
V.C. 440'
M.O. -1.48'
K = 163
PVI Sta. 751+00
El. 314.50
V.C. 310'
M.O. +1.14'
K = 106
Levee Sta. 17+30.09
LR 310 Seg. 6 ℄ Sta. 746+50
L.R. 310 - Seg. 6
℄ Sta. 745+90
= L R 06017 ℄ Sta. 10+00
End Relocation
L.R 310 - Seg. 6
℄ Sta. 752+80
PVI Sta. 741+00
El. = 322.07
V.C = 180'
M.O. = +0.24
K = 165
℄ Northkill Creek
PVT.
+0.83%
PVC.
-2.10%
PVT.
PVC.
+0.59%
PVT.
PVC.
-0.50%
330
320
310
300
290
754
753
+55
752
751
750
+45
749
+20
748
747
746
745
744
+80
743
742
+90
741
740
+10
739
PROFILE - L.I



HORIZONTAL ALIGNMENT - L.R. 310-SEG 6



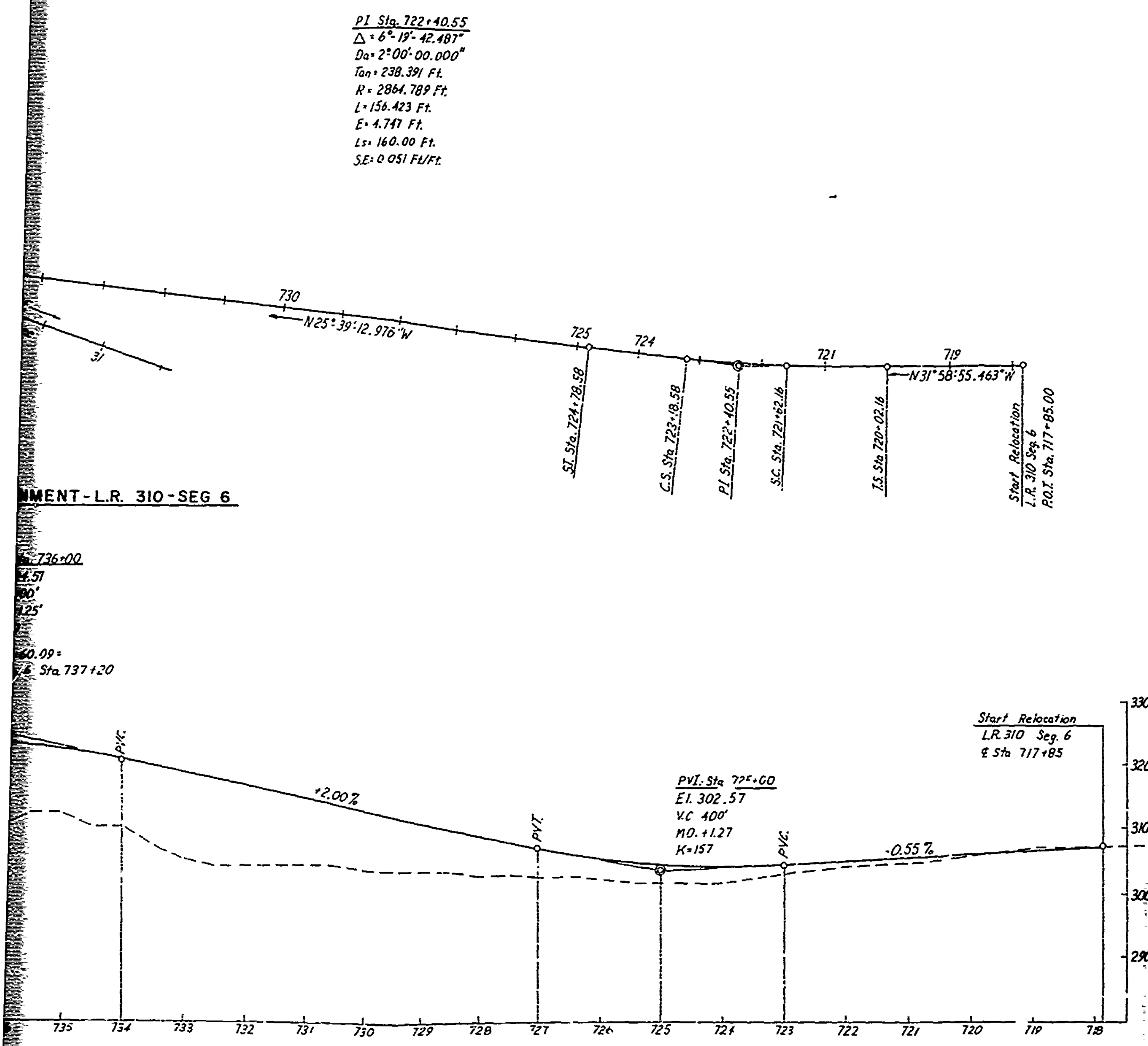
L.R. 310-SEG 6

SCALE IN FEET

100 0 100 200

SCHUYLKILL
TULPEHOCKE
BLUE MA
BERNVILLE PR
HIGHWAY
ALIGNMENT
SHE

2



SCALE IN FEET

100 0 100 200

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

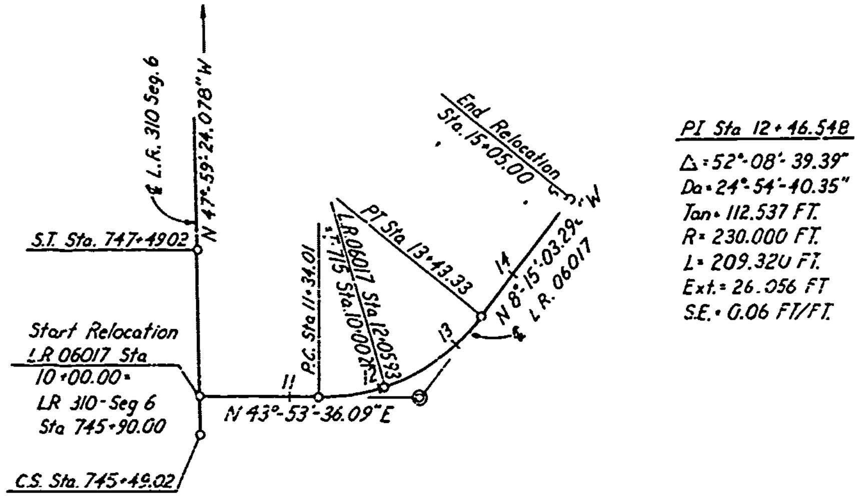
BLUE MARSH LAKE

BERNVILLE PROTECTIVE WORKS

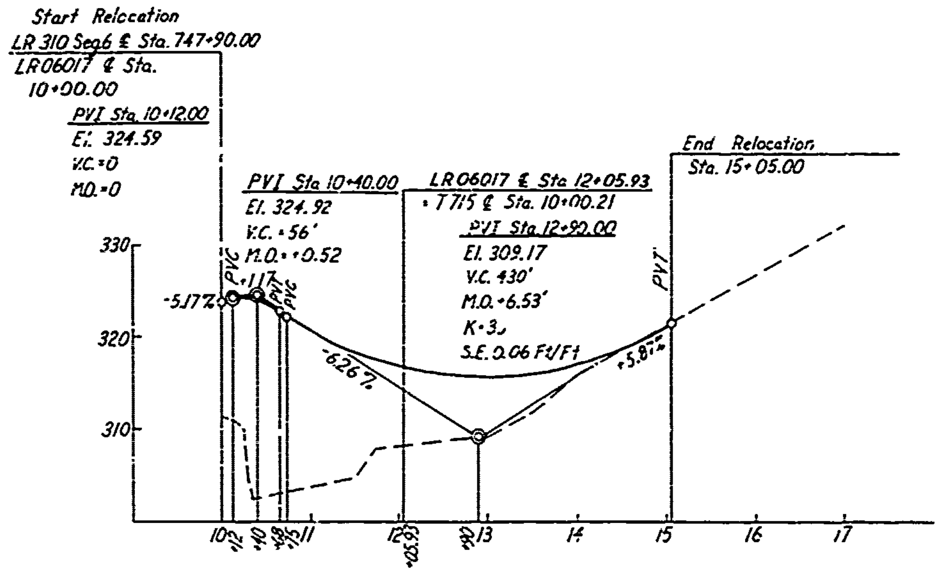
HIGHWAY RELOCATION
ALIGNMENT AND PROFILE

SHEET I

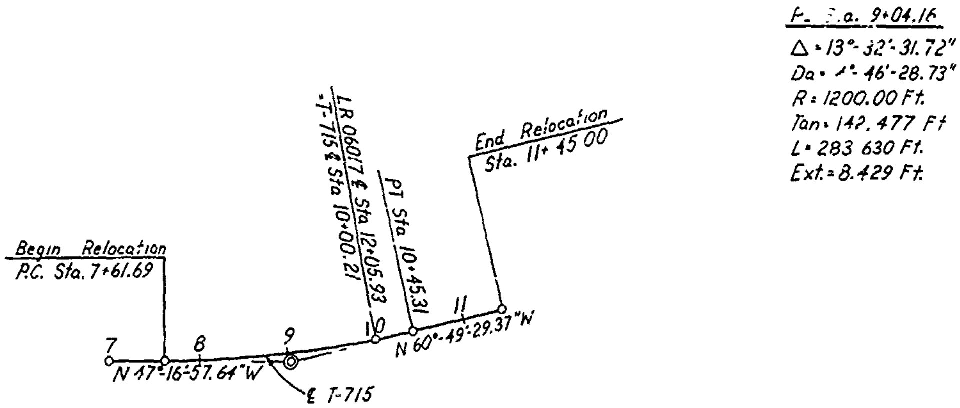
D.M. NO. 13 PLATE 3



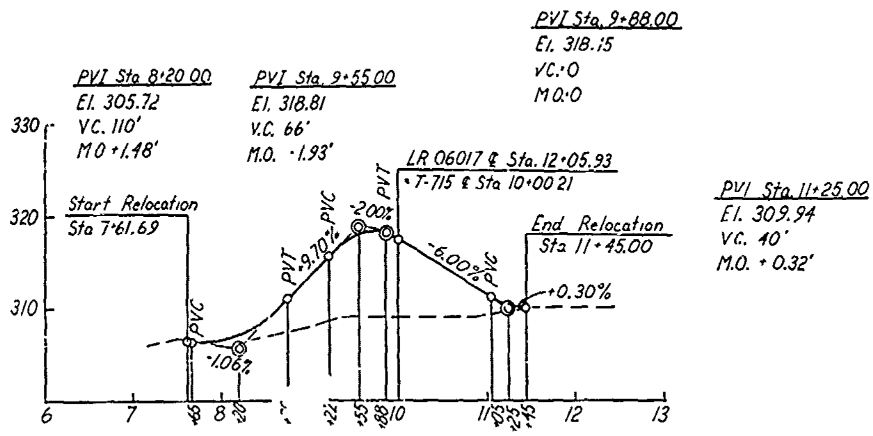
HORIZONTAL ALIGNMENT - L.R. 06017



PROFILE - L.R. 06017



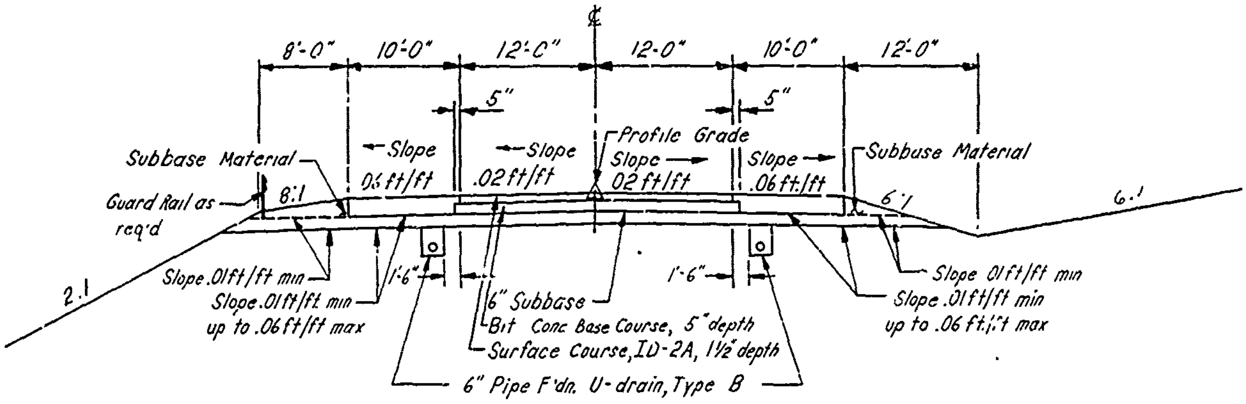
HORIZONTAL ALIGNMENT - T-715



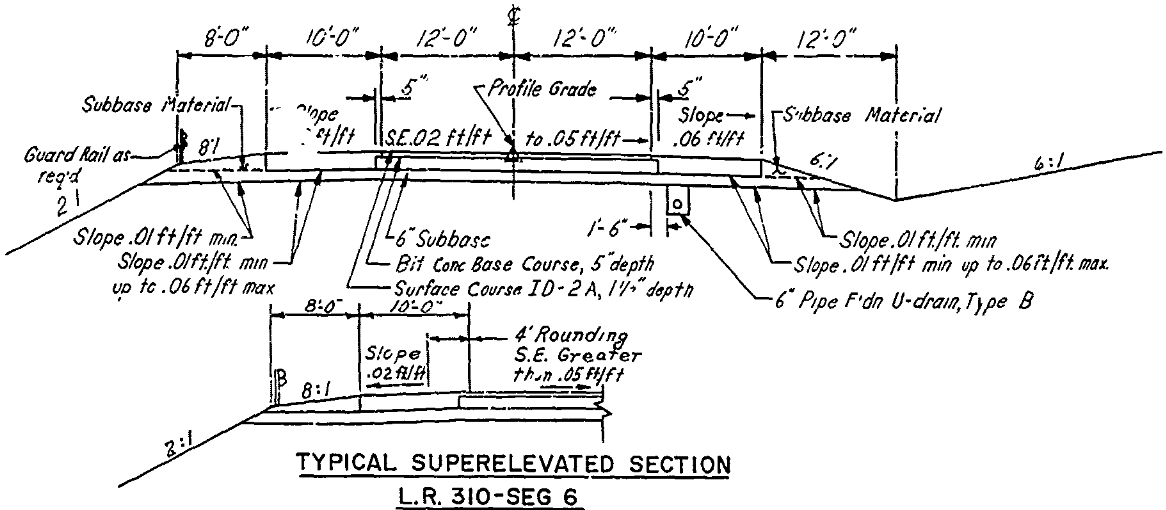
PROFILE - T-715

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
HIGHWAY RELOCATION
ALIGNMENT AND PROFILE
SHEET 2

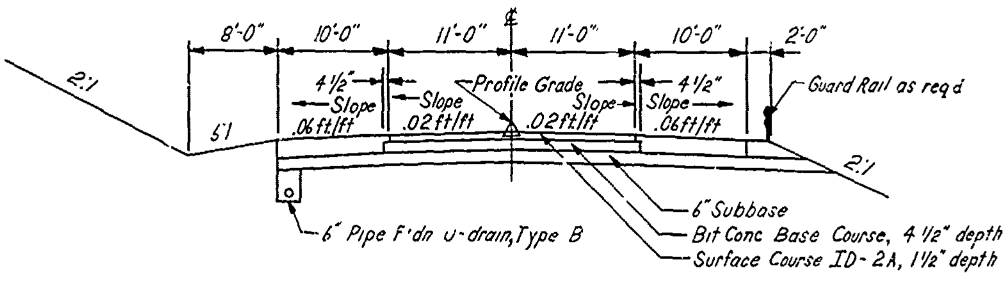
D. M. NO. 13 PLATE



TYPICAL NORMAL SECTION
L.R. 310-SEG 6
STA. 717+85 TO STA. 718+87
STA. 725+94 TO STA. 735+41

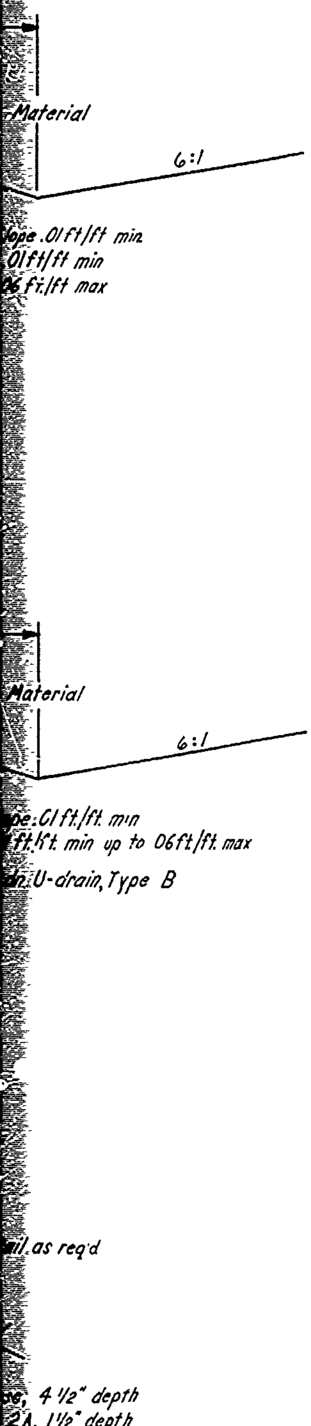


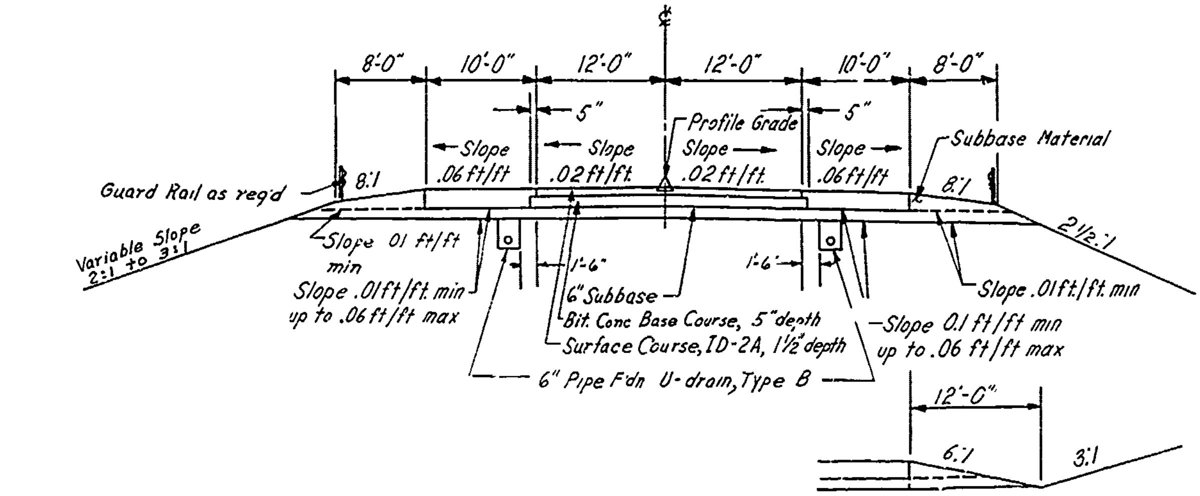
TYPICAL SUPERELEVATED SECTION
L.R. 310-SEG 6
STA. 718+87 TO STA. 725+94
STA. 735+41 TO STA. 737+20



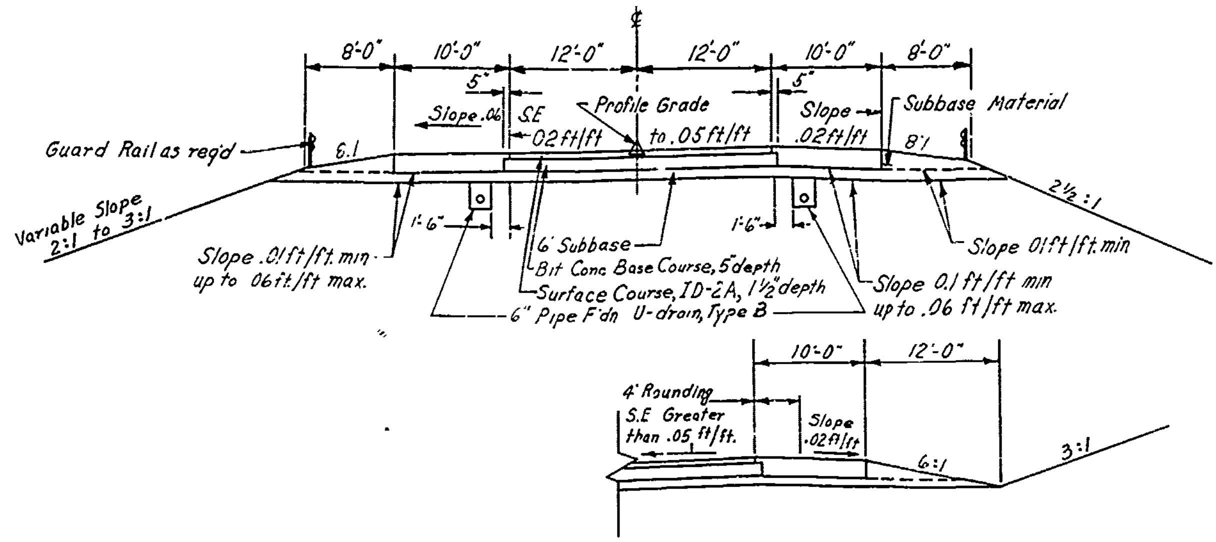
TYPICAL NORMAL SECTION
L.R. 06017

Notes





TYPICAL NORMAL SECTION ON LEVEE
L.R. 310- SEG. 6
STA. 748+64 TO STA. 752+80



TYPICAL SUPERELEVATED SECTION ON LEVEE
L.R. 310-SEG 6
STA. 737+20 TO STA. 748+64

Notes:

1. All shoulders are paved unless noted.
2. For rip-rap and core details of L.R. 310 - Segment 6 Typical Sections On Levee, See Levee Cross Section Sheets.

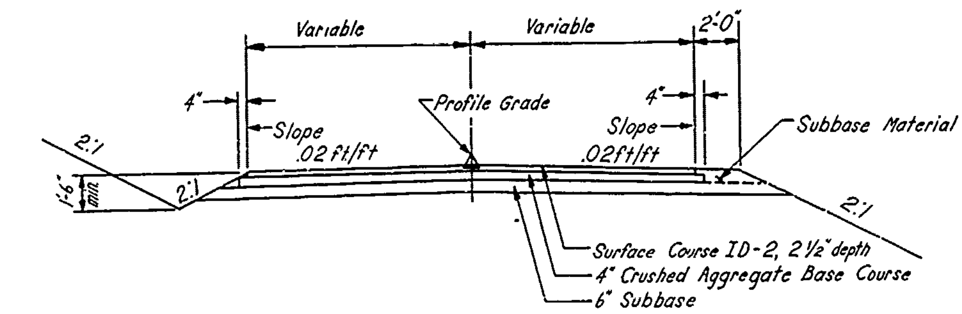
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE

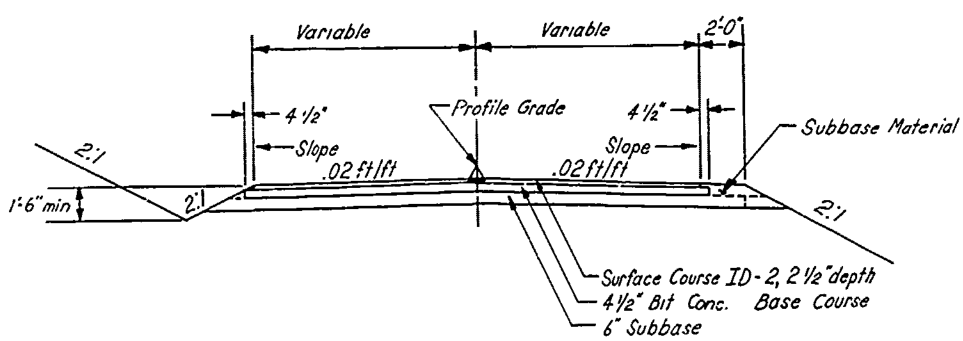
BERNVILLE PROTECTIVE WORKS

HIGHWAY SECTIONS
SHEET 1

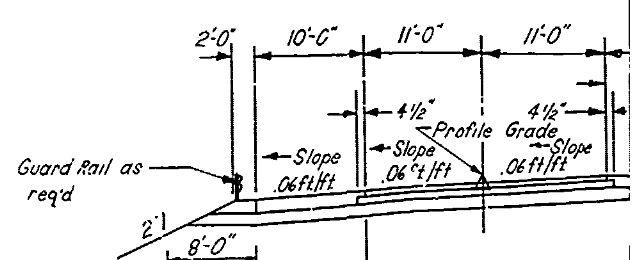
D.M. NO. 13 PLATE 1



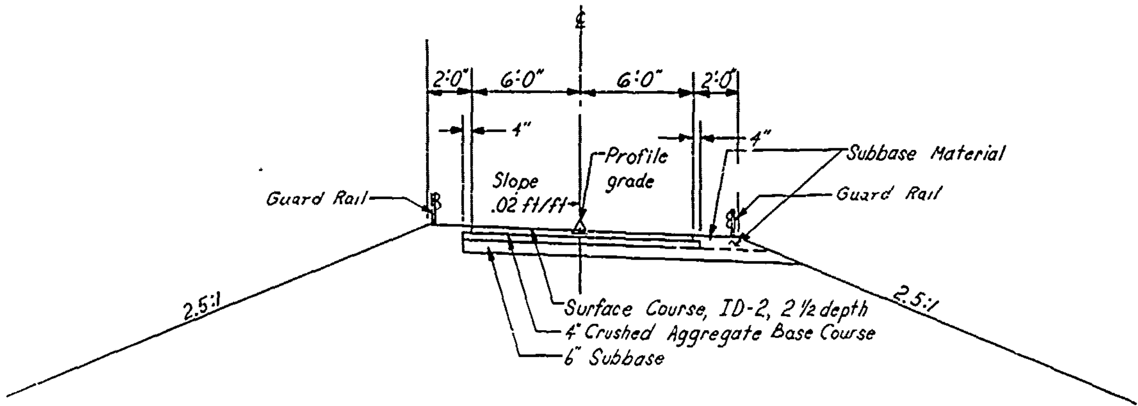
TYPICAL SECTION
DRIVEWAY



TYPICAL SECTION
CONNECTING STREETS (BOROUGH OF BERNVILLE)

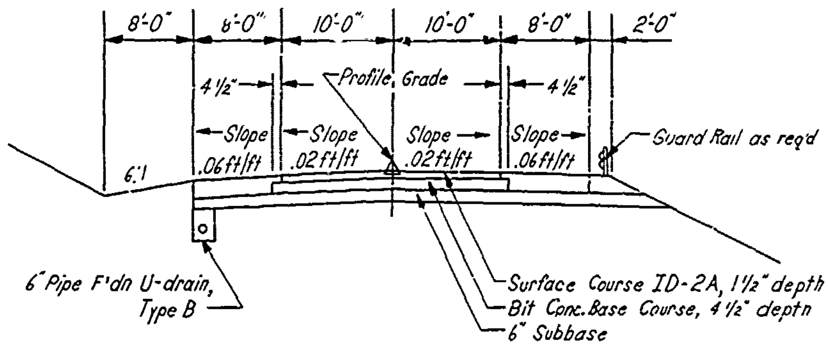


TYPICAL SUPERELEVATED
L.R. 06017



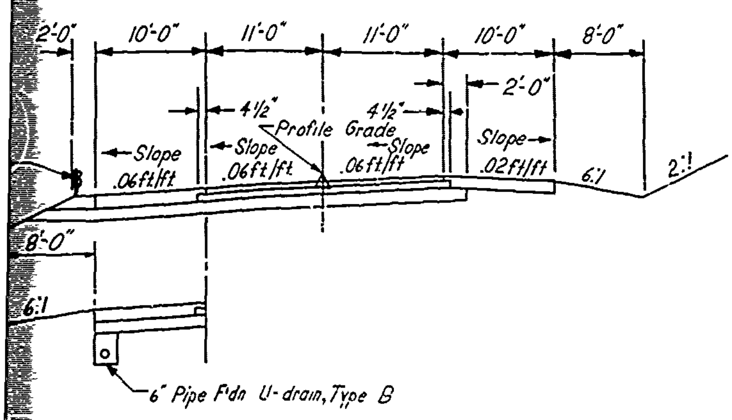
TYPICAL SECTION

ACCESS ROA. TO PUMPING STATION



TYPICAL NORMAL SECTION

T-715



TYPICAL SUPERELEVATED SECTION

L.R. 06017

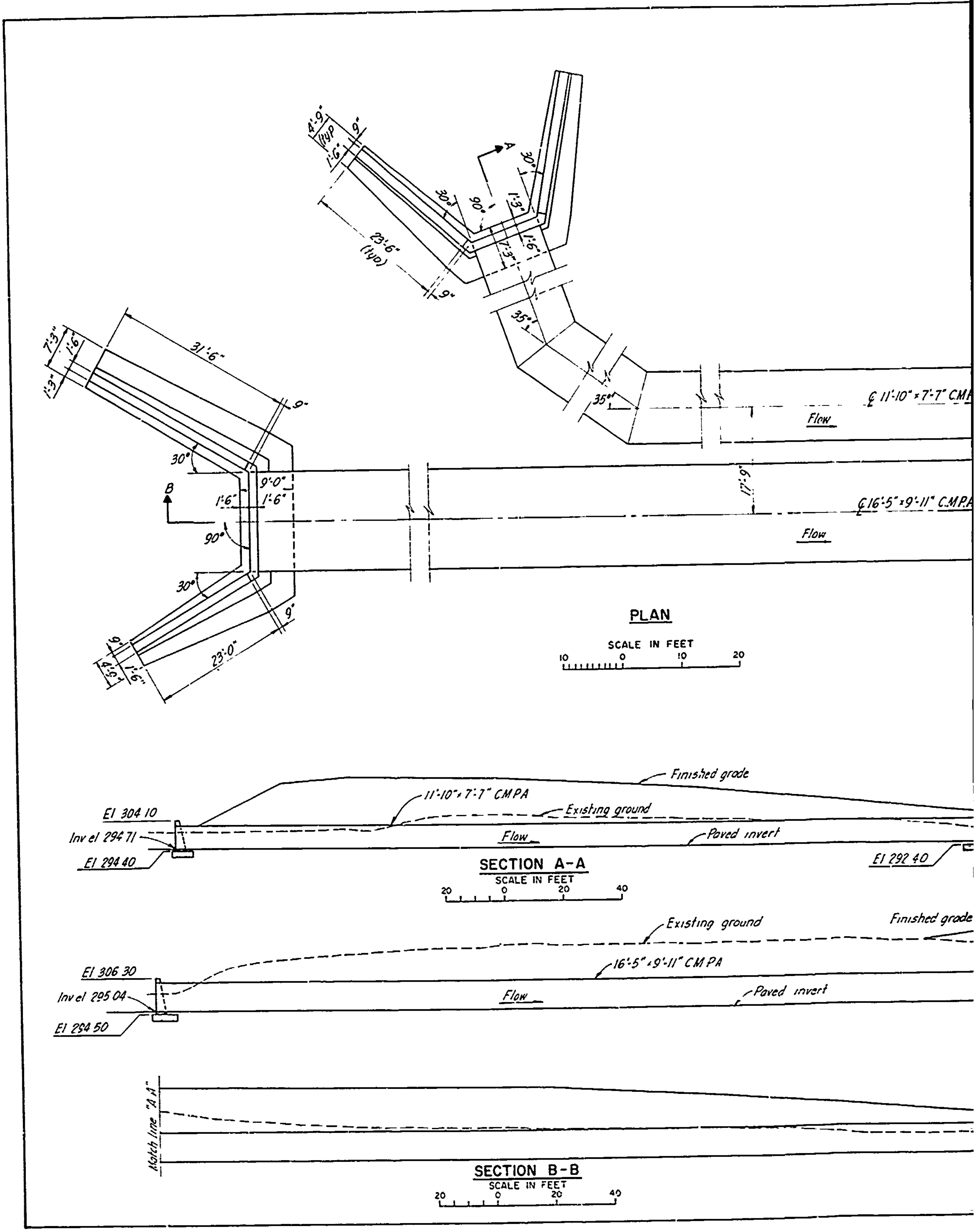
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE

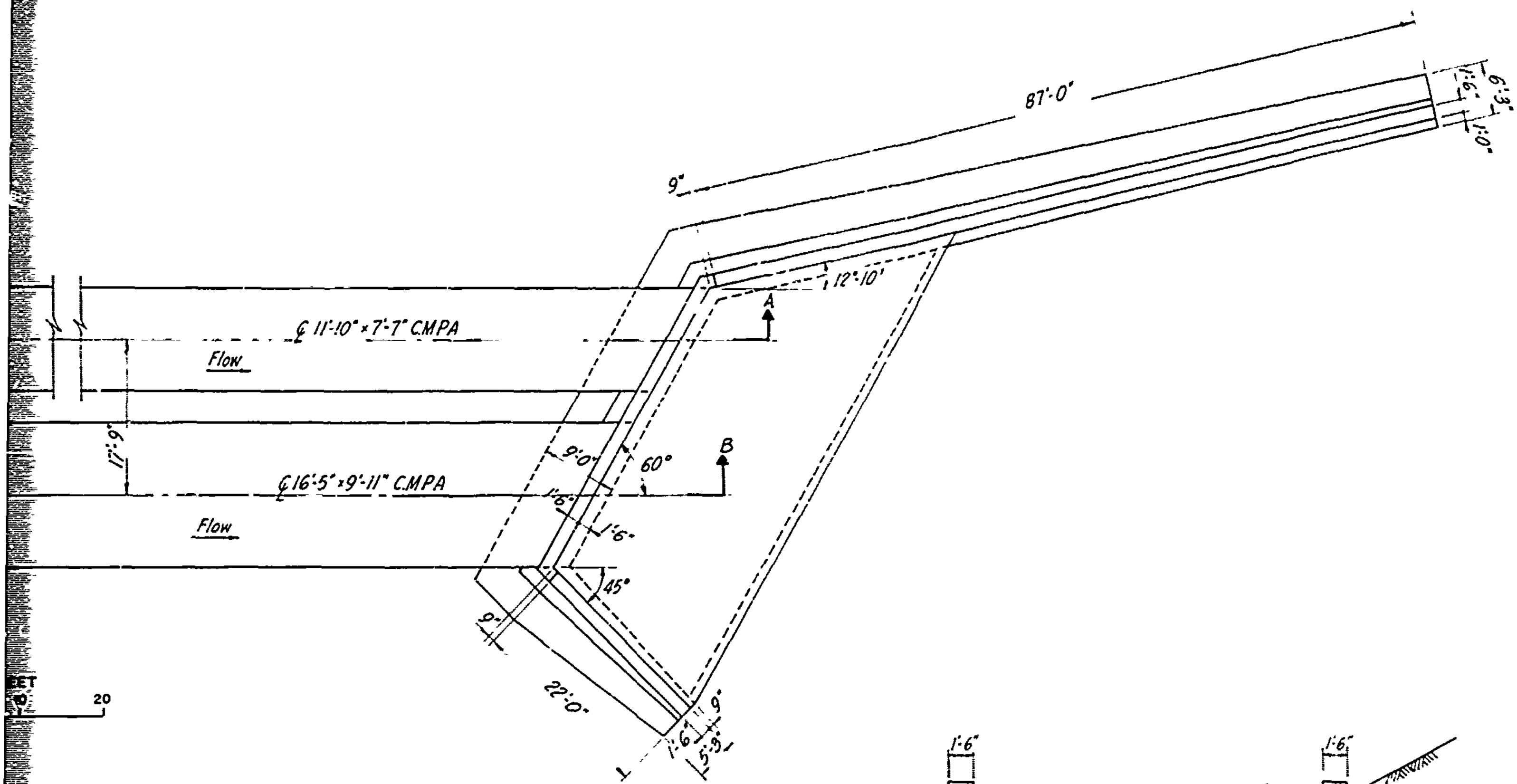
BERNVILLE PROTECTIVE WORKS

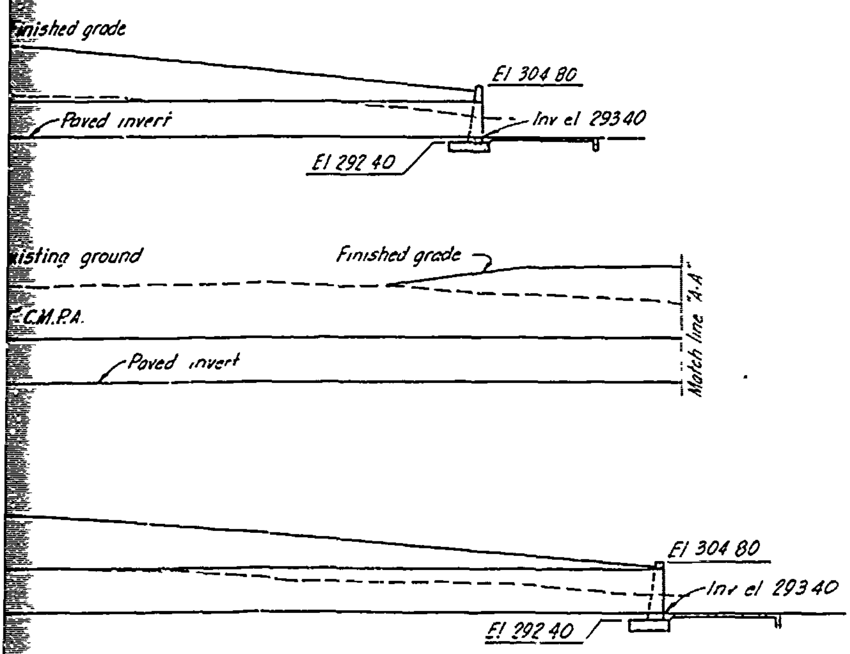
HIGHWAY SECTIONS
SHEET 2

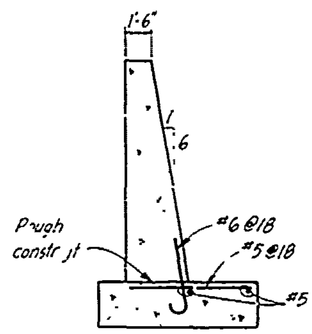
D.M. NO. 13 PLATE I



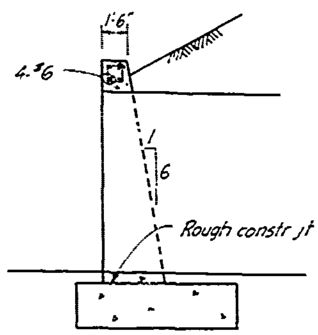
A
4'-9" (typ)
9"
1'-6"
30°
90°
1'-3"
23'-6" (typ)
7'-3"
1'-6"
9"
35°
35°
℄ 11'-10" x 7'-7" CMP
Flow
7'-3"
1'-6"
1'-3"
31'-6"
9"
30°
9'-0"
B
1'-6"
1'-6"
17'-9"
90°
℄ 16'-5" x 9'-11" CMPA
Flow
30°
9"
9"
4'-9"
1'-6"
23'-0"
PLAN
SCALE IN FEET
10 0 10 20
Finished grade
11'-10" x 7'-7" CMPA
El 304 10
Existing ground
Inv el 294 71
Flow
Paved invert
El 294 40
El 292 40
SECTION A-A
SCALE IN FEET
20 0 20 40
Existing ground
Finished grade
El 306 30
16'-5" x 9'-11" CMPA
Inv el 295 04
Flow
Paved invert
El 294 50
Match line "A A"
SECTION B-B
SCALE IN FEET
20 0 20 40







TYPICAL WINGWALL



TYPICAL ENDWALL

SCALE IN FEET

1 0 5 10 15

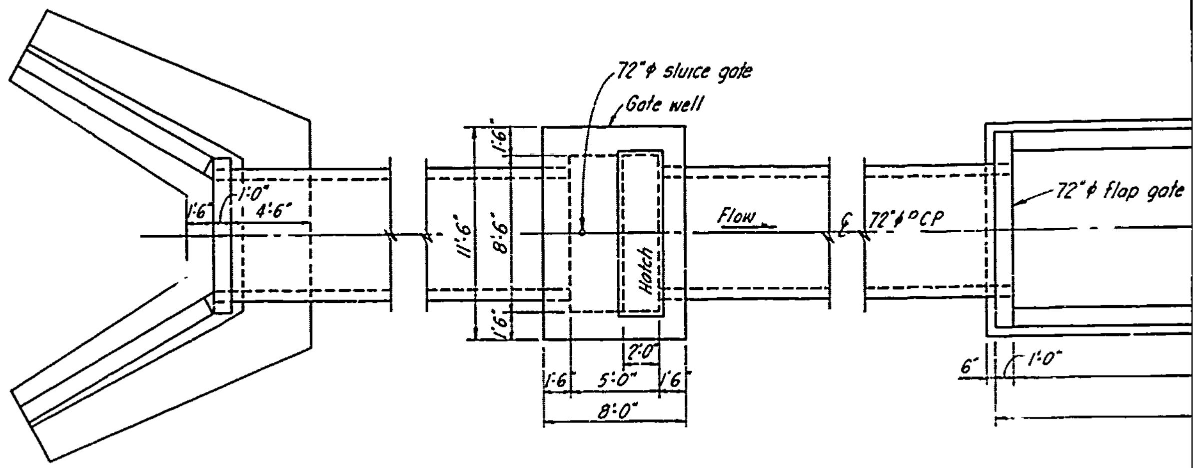
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE

BERNVILLE PROTECTIVE WORKS

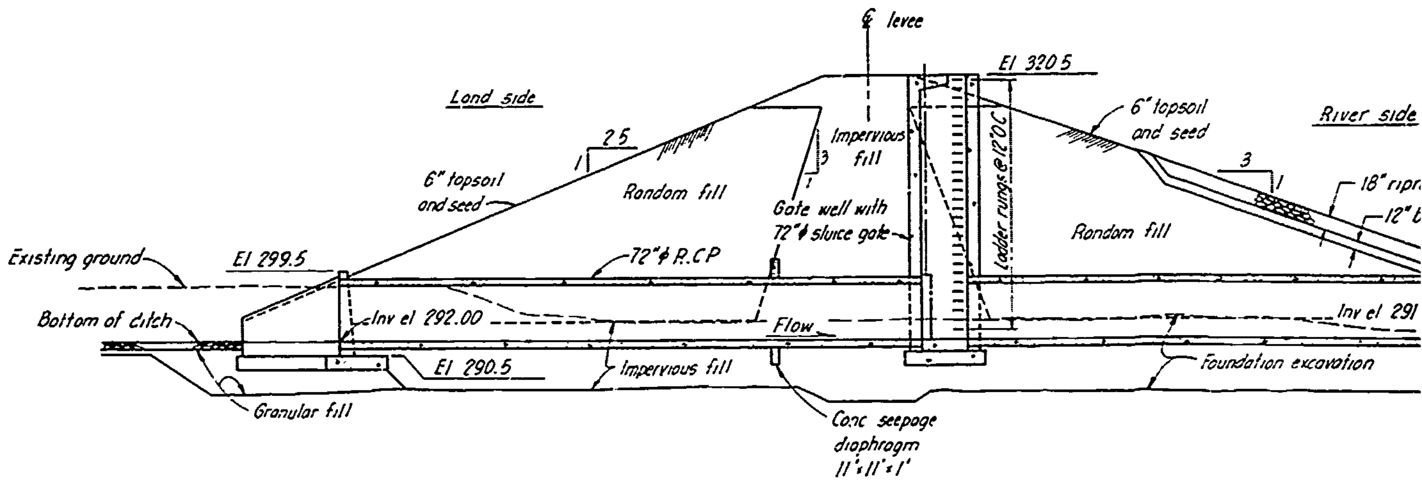
UPPER DRAINAGE STRUCTURE

D.M. NO. 13 PLATE 20



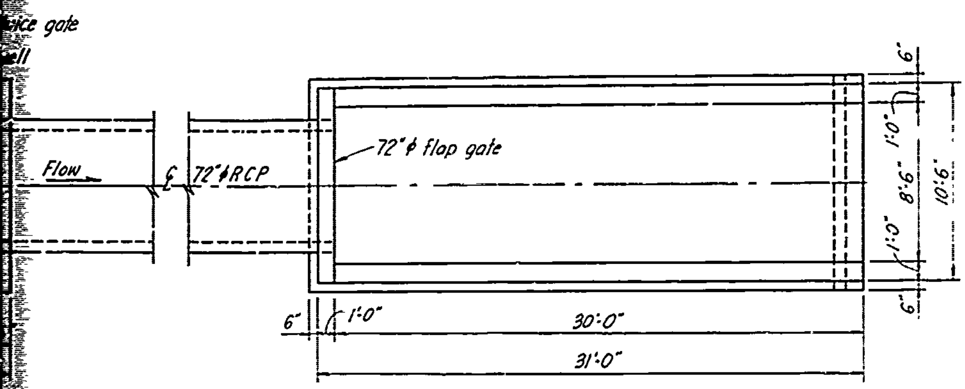
PLAN - GRAVITY OUTLET

SCALE IN FEET
5 0 5 10



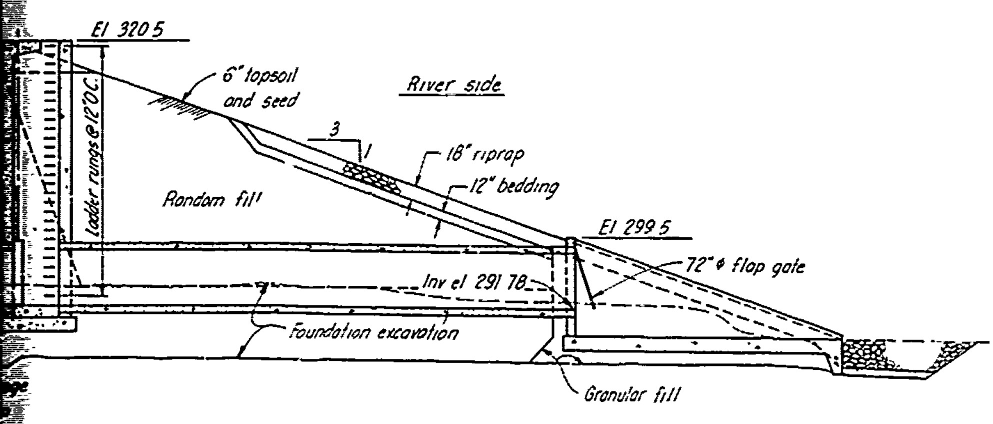
SECTION - GRAVITY OUTLET

SCALE IN FEET
10 0 10 20



GRAVITY OUTLET

SCALE IN FEET
0 5 10

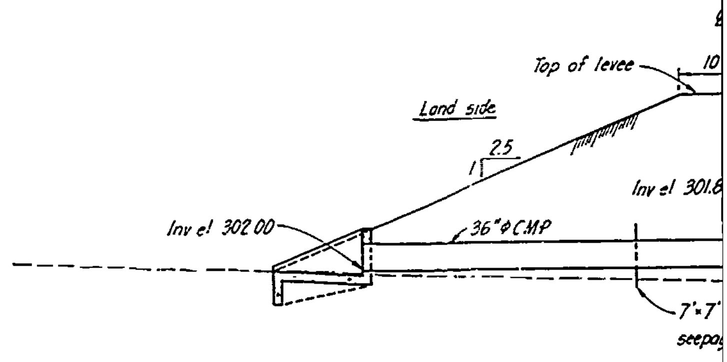


OUTLET

20

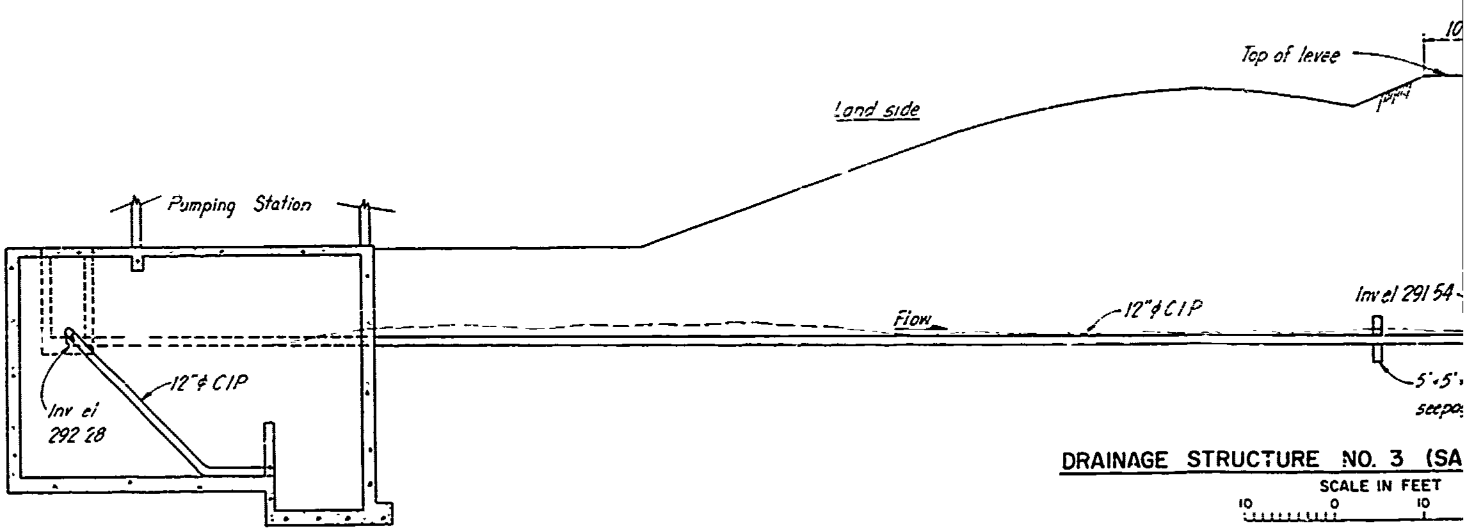
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

DRAINAGE STRUCTURE NO. 1



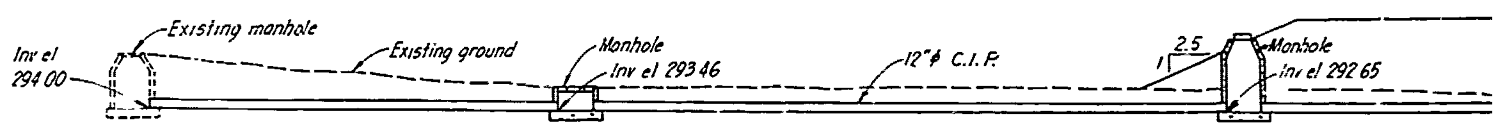
DRAINAGE STRUCT

10



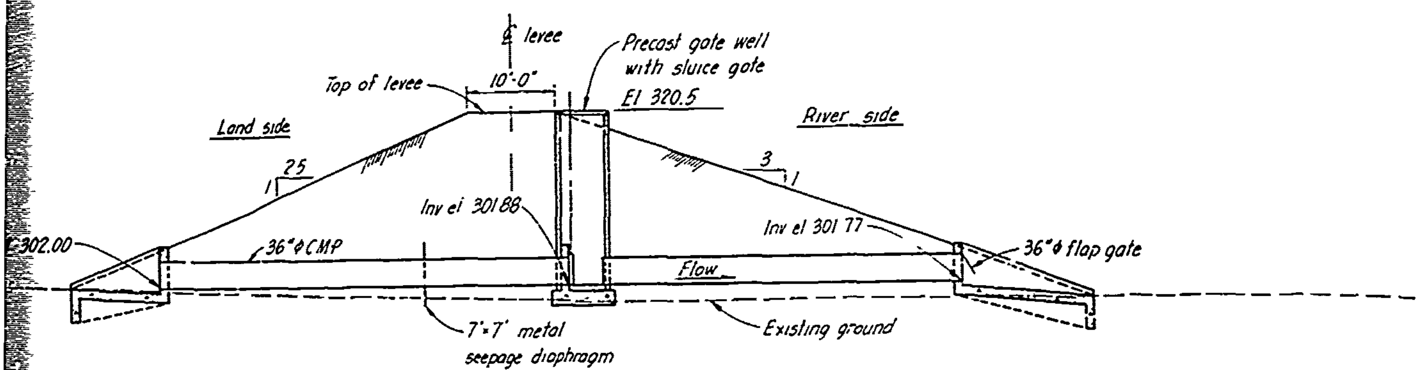
DRAINAGE STRUCTURE NO. 3 (SA

SCALE IN FEET
10 0 10



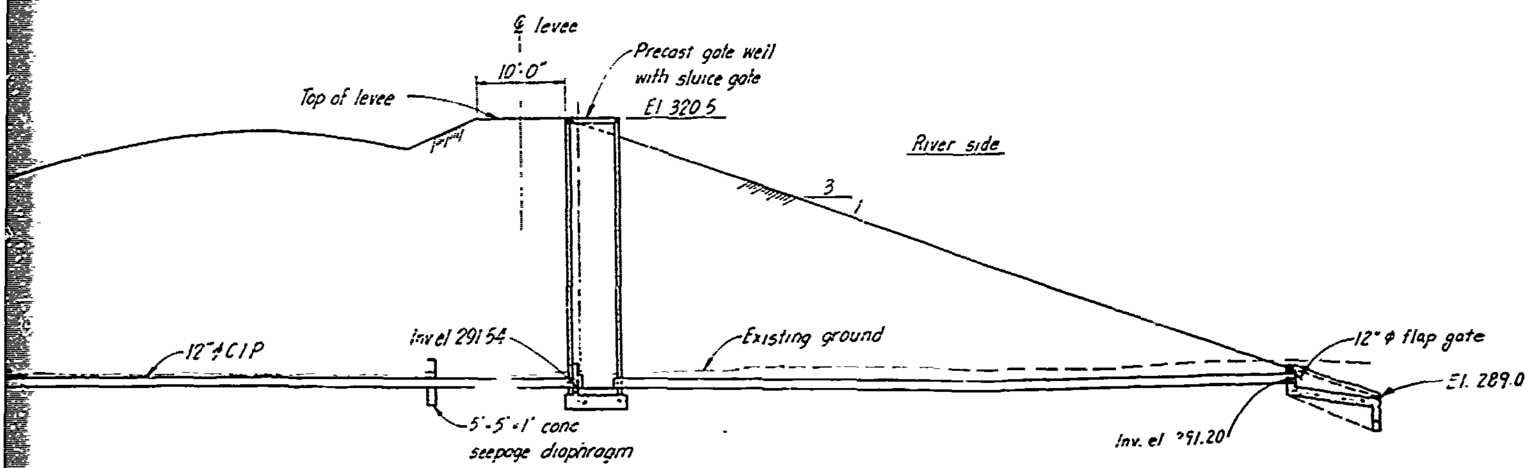
SEWER LINE TO SANITARY EFFLUENT OUTFALL

SCALE IN FEET
10 0 10 20



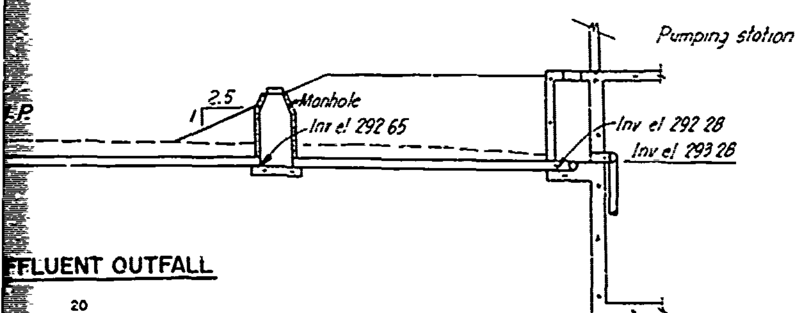
DRAINAGE STRUCTURE NO. 2 (FLANKING LEVEE)

SCALE IN FEET
10 0 10 20



DRAINAGE STRUCTURE NO. 3 (SANITARY EFFLUENT OUTFALL)

SCALE IN FEET
10 0 10 20

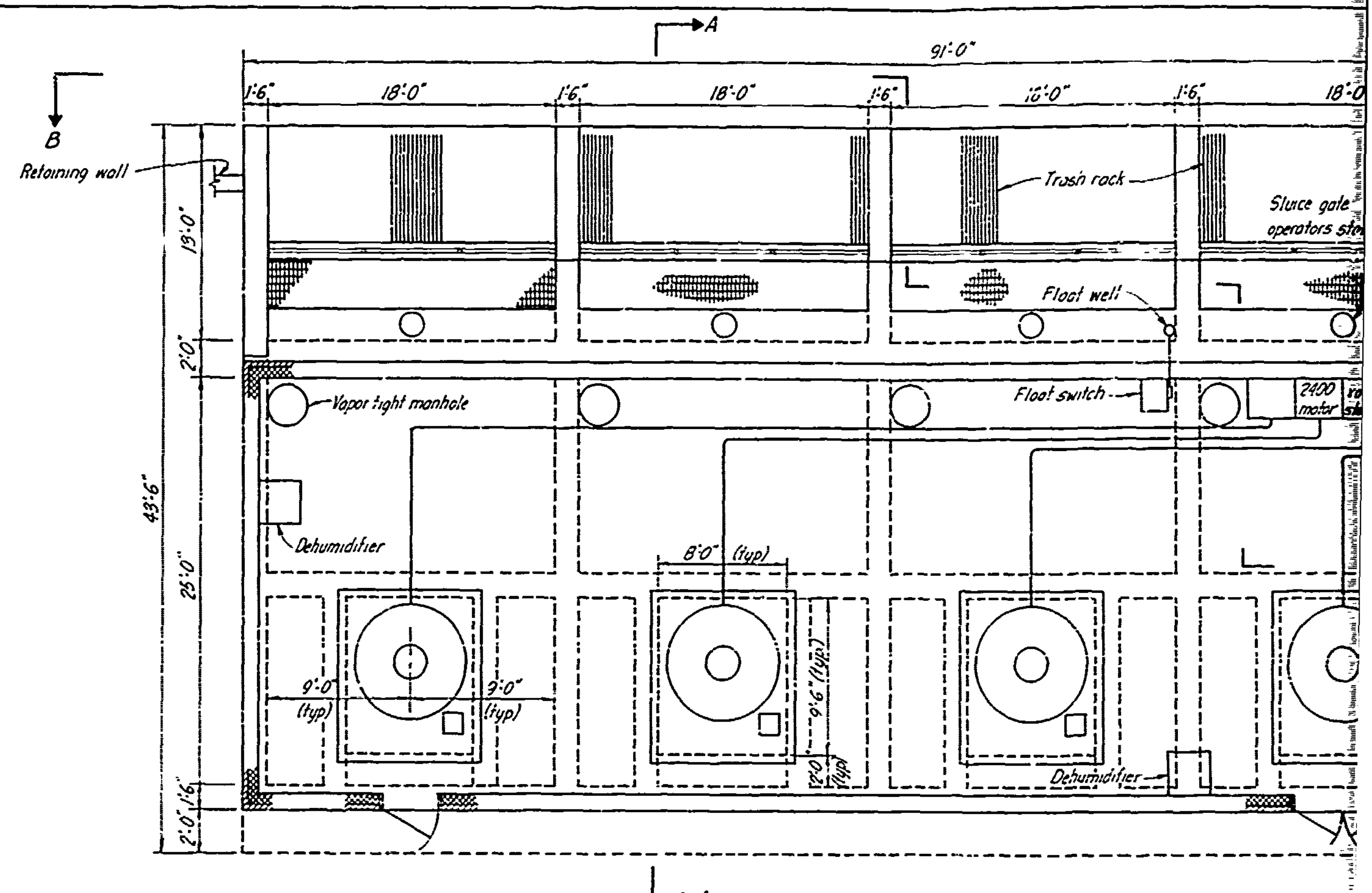


FFLUENT OUTFALL

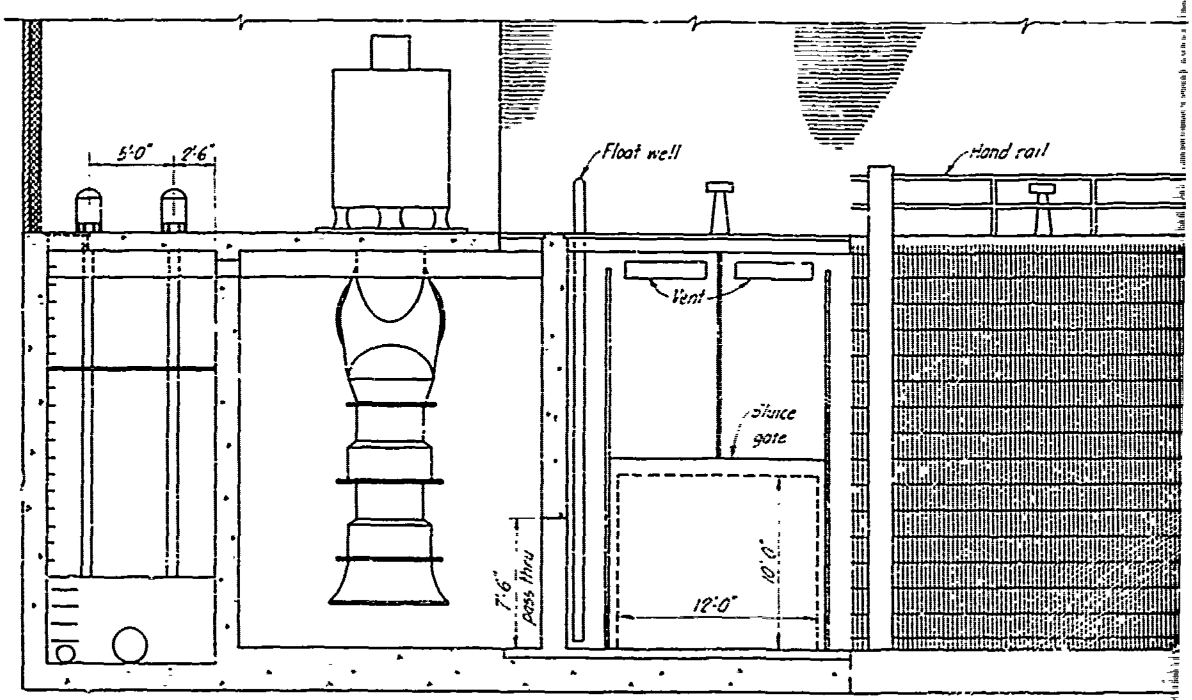
20

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

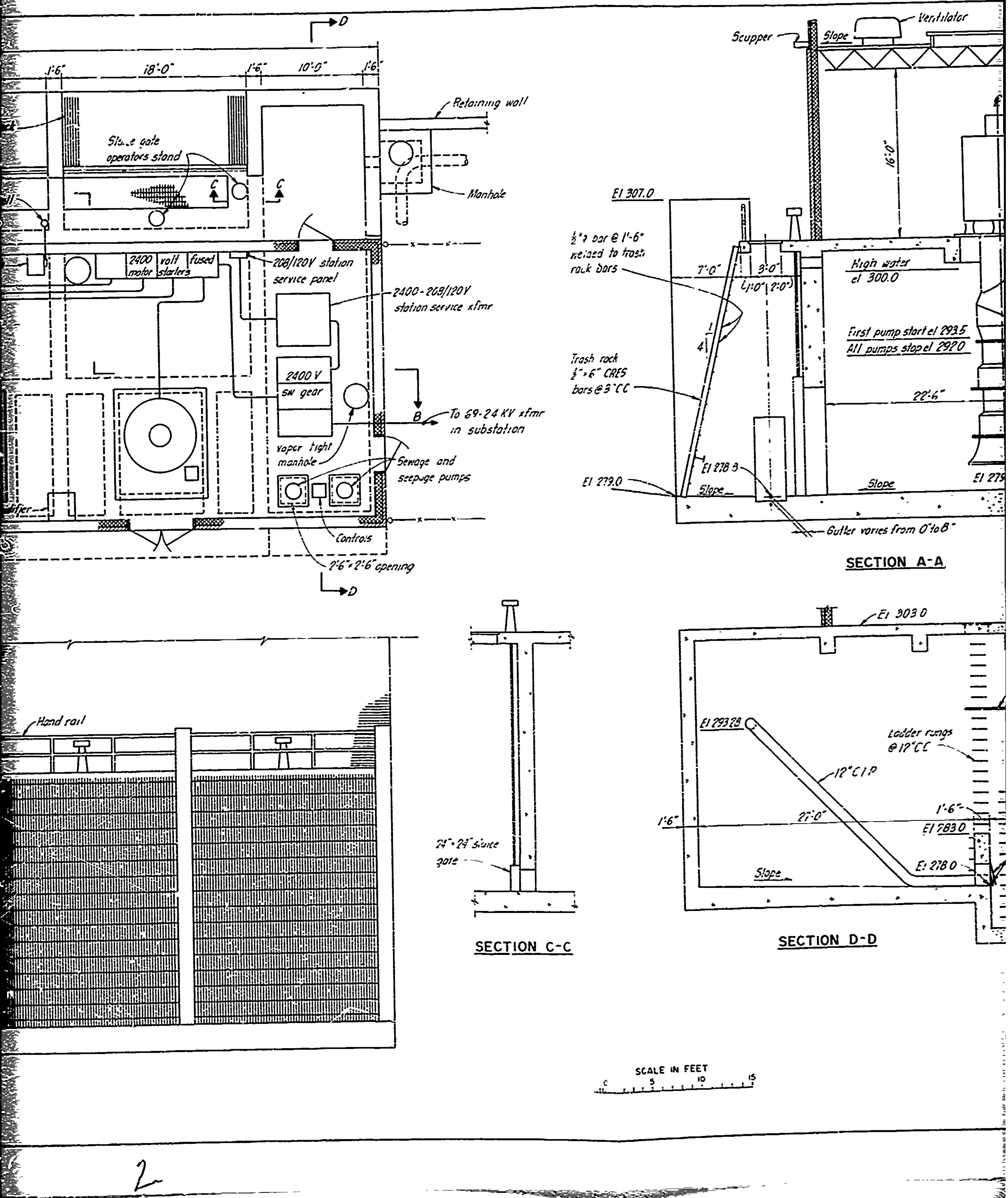
DRAINAGE STRUCTURES
NO. 2 & NO. 3

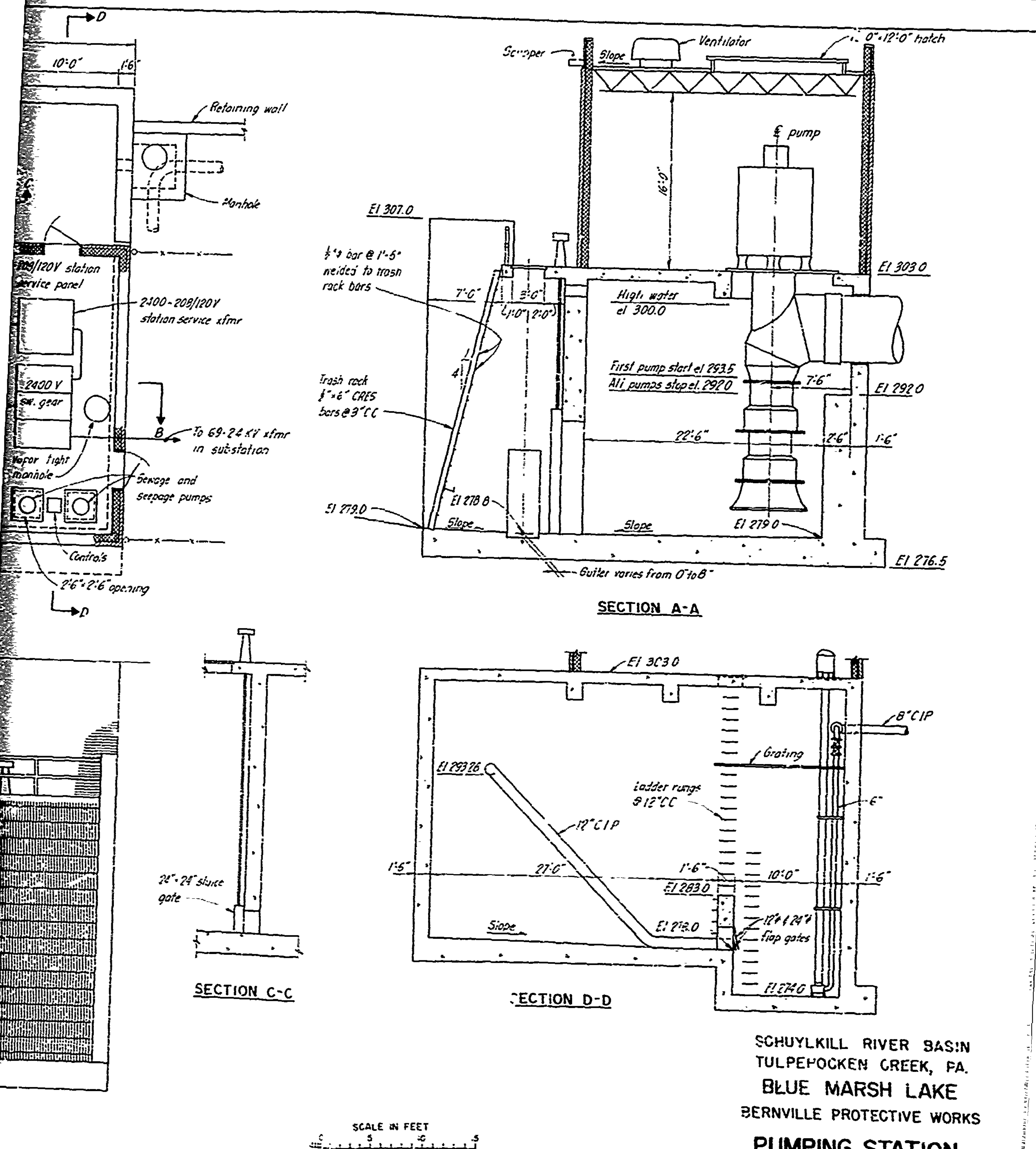


PLAN



SECTION B-B


D
1'-6"
18'-0"
1'-6"
10'-0"
1'-6"
Retaining wall
Sluice gate operators stand
C
C
Manhole
2400 volt motor starters
fused
208/120V station service panel
2400-208/120V station service xfmr
2400 V SW gear
B
To 69-2.4 KV xfmr in substation
Vapor tight manhole
Sewage and seepage pumps
Controls
2'-6" x 2'-6" opening
D
Scupper
Slope
Ventilator
16'-0"
El 307.0
½" ⌀ bar @ 1'-6" welded to trash rack bars
7'-0"
3'-0"
1'-0"
2'-0"
High water el 300.0
1
4
First pump start el 293.5
All pumps stop el 292.0
Trash rack ½" x 6" CRES bars @ 3" CC
22'-6"
El 278.3
El 279.0
Slope
Slope
Gutter varies from 0" to 8"
SECTION A-A
Hand rail
24" x 24" sluice gate
SECTION C-C
El 303.0
El 293.28
Ladder rungs @ 12" CC
12" C I P
27'-0"
1'-6"
1'-6"
El 283.0
El 278.0
Slope
SECTION D-D
SCALE IN FEET
0
5
10
15
2



SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

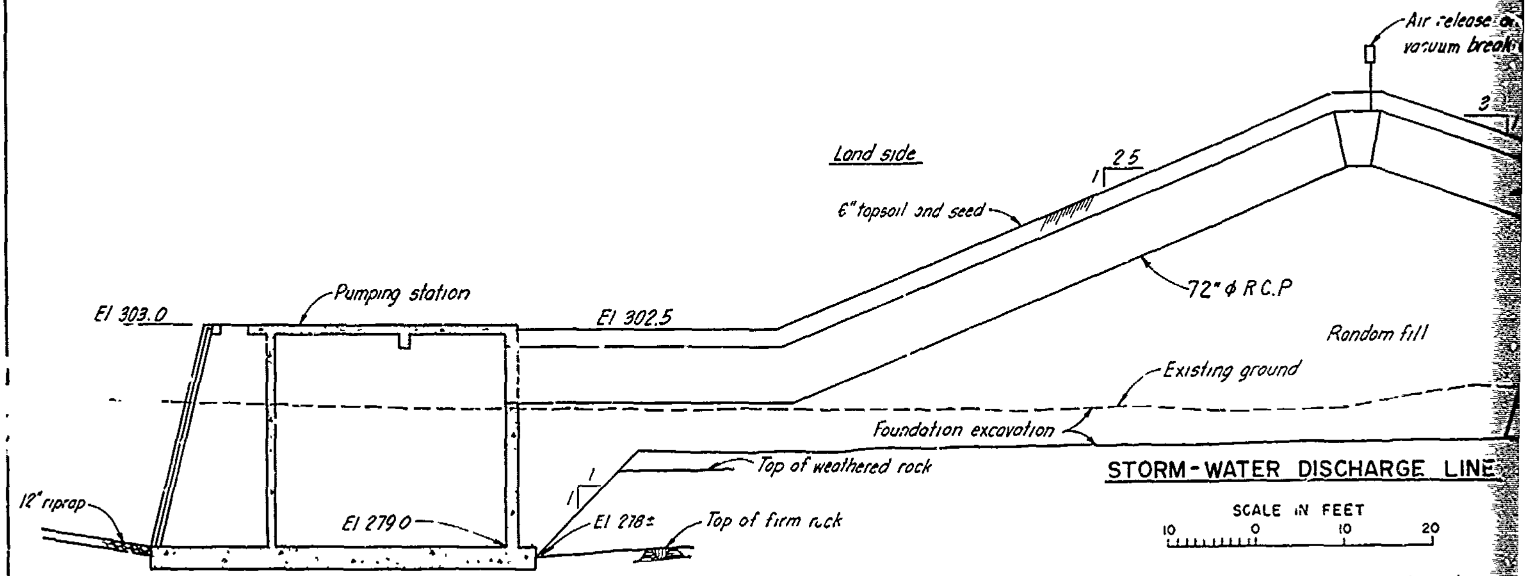
BLUE MARSH LAKE

BERNVILLE PROTECTIVE WORKS

PUMPING STATION

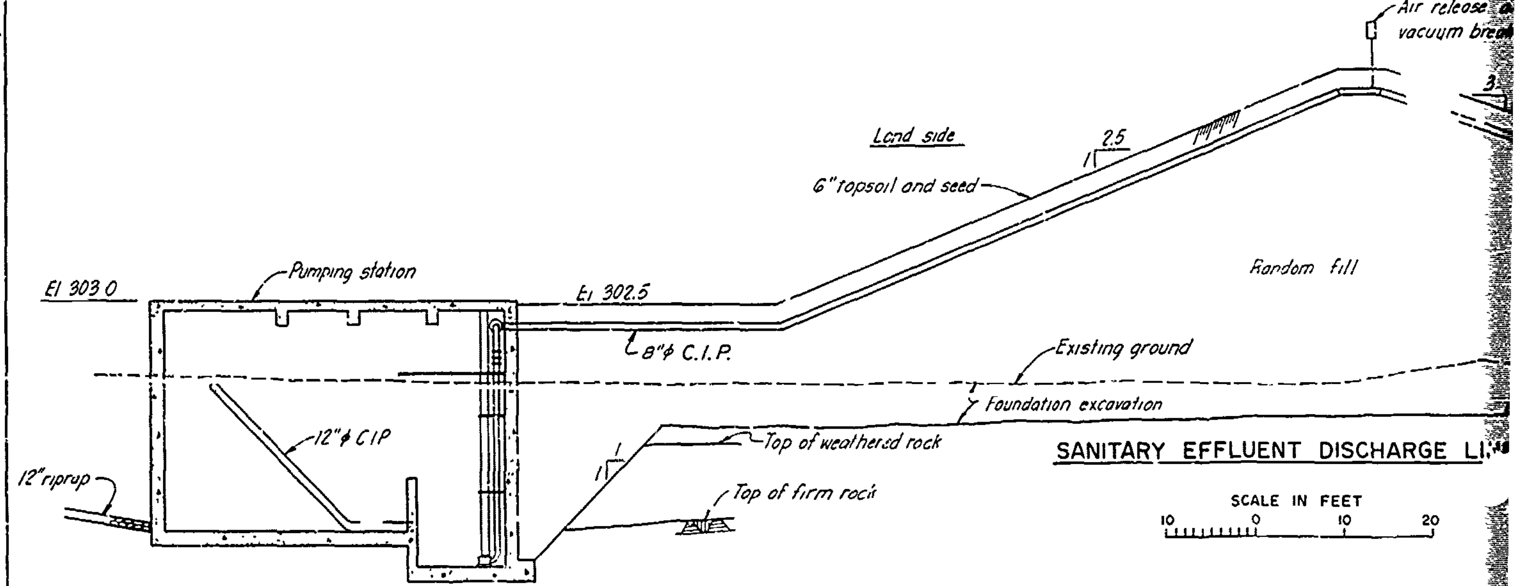
PLAN & SECTIONS

D.M. NO. 13 PLATE



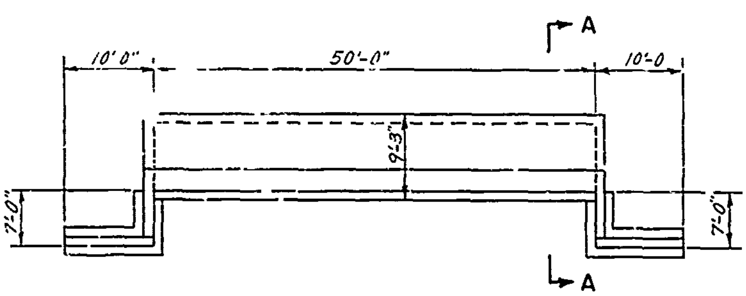
STORM-WATER DISCHARGE LINE

SCALE IN FEET
10 0 10 20



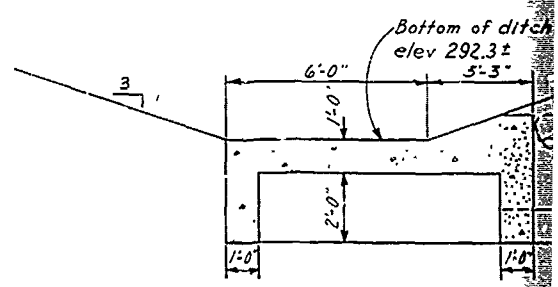
SANITARY EFFLUENT DISCHARGE LINE

SCALE IN FEET
10 0 10 20



PLAN

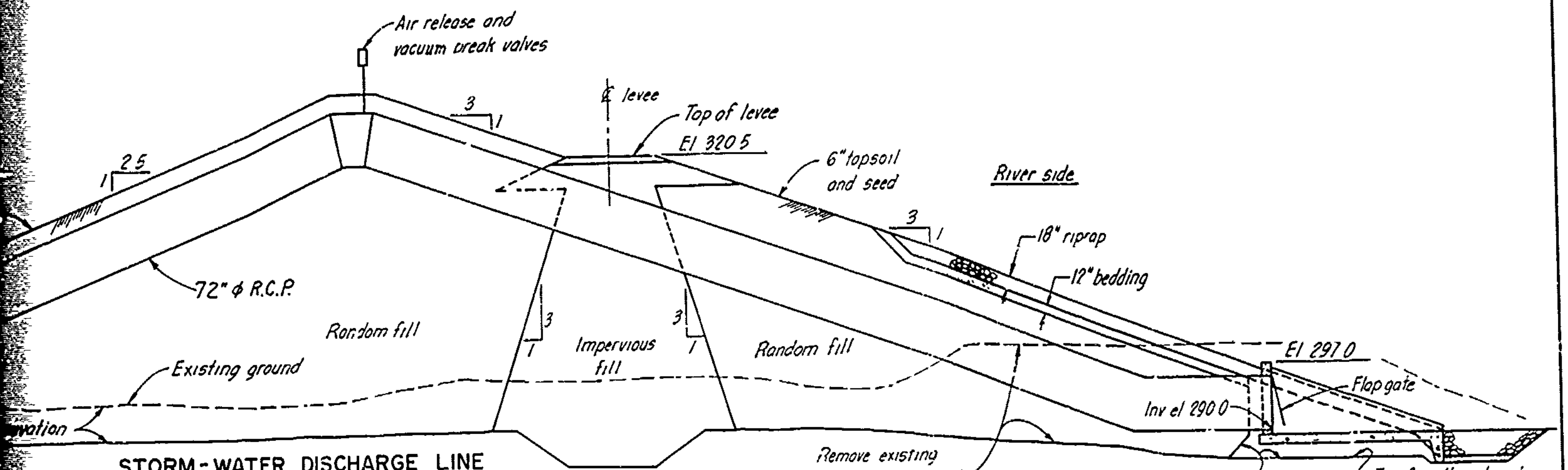
SCALE IN FEET
10 0 10 20



SECTION A-A

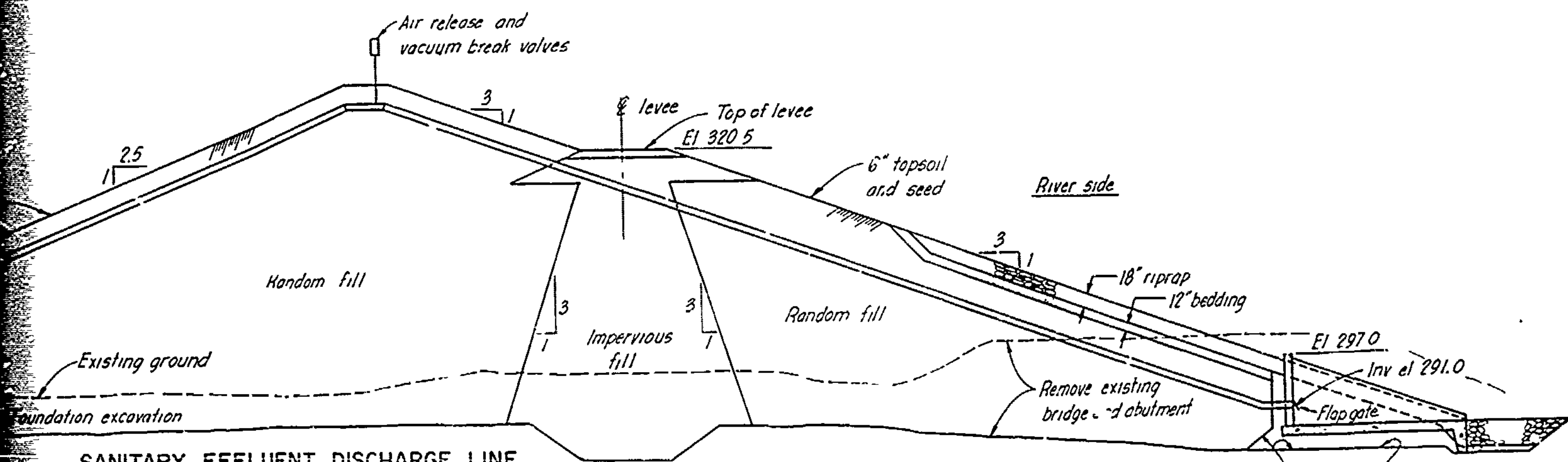
SCALE IN FEET
1 0 1 2 3 4 5 6

CONTROL SILL



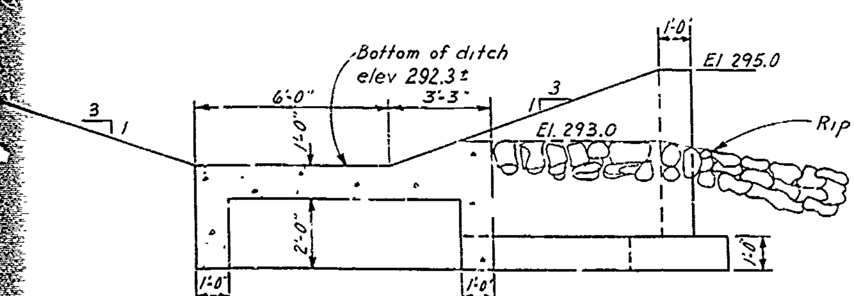
STORM-WATER DISCHARGE LINE

SCALE IN FEET
10 0 10 20



SANITARY EFFLUENT DISCHARGE LINE

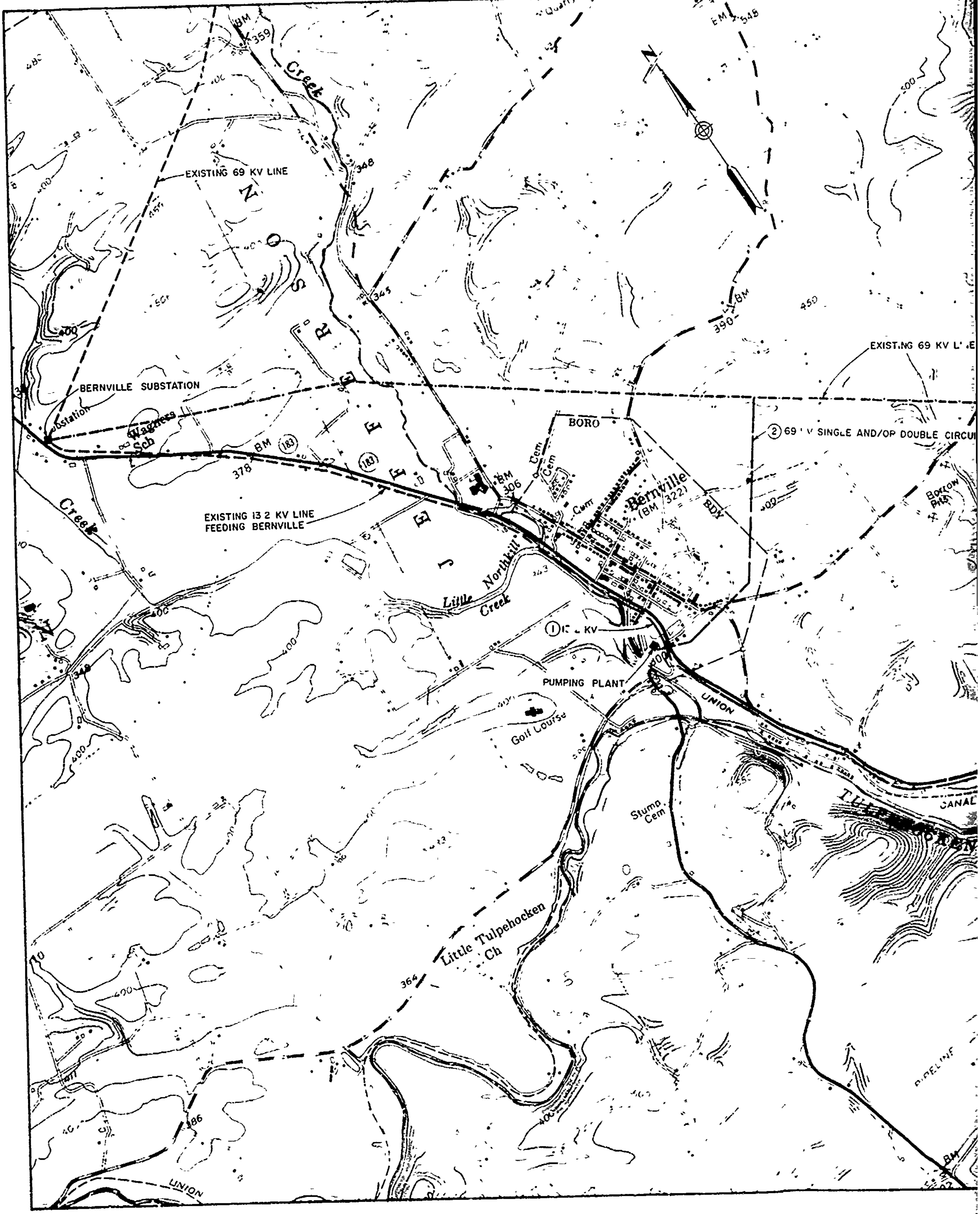
SCALE IN FEET
10 0 10 20

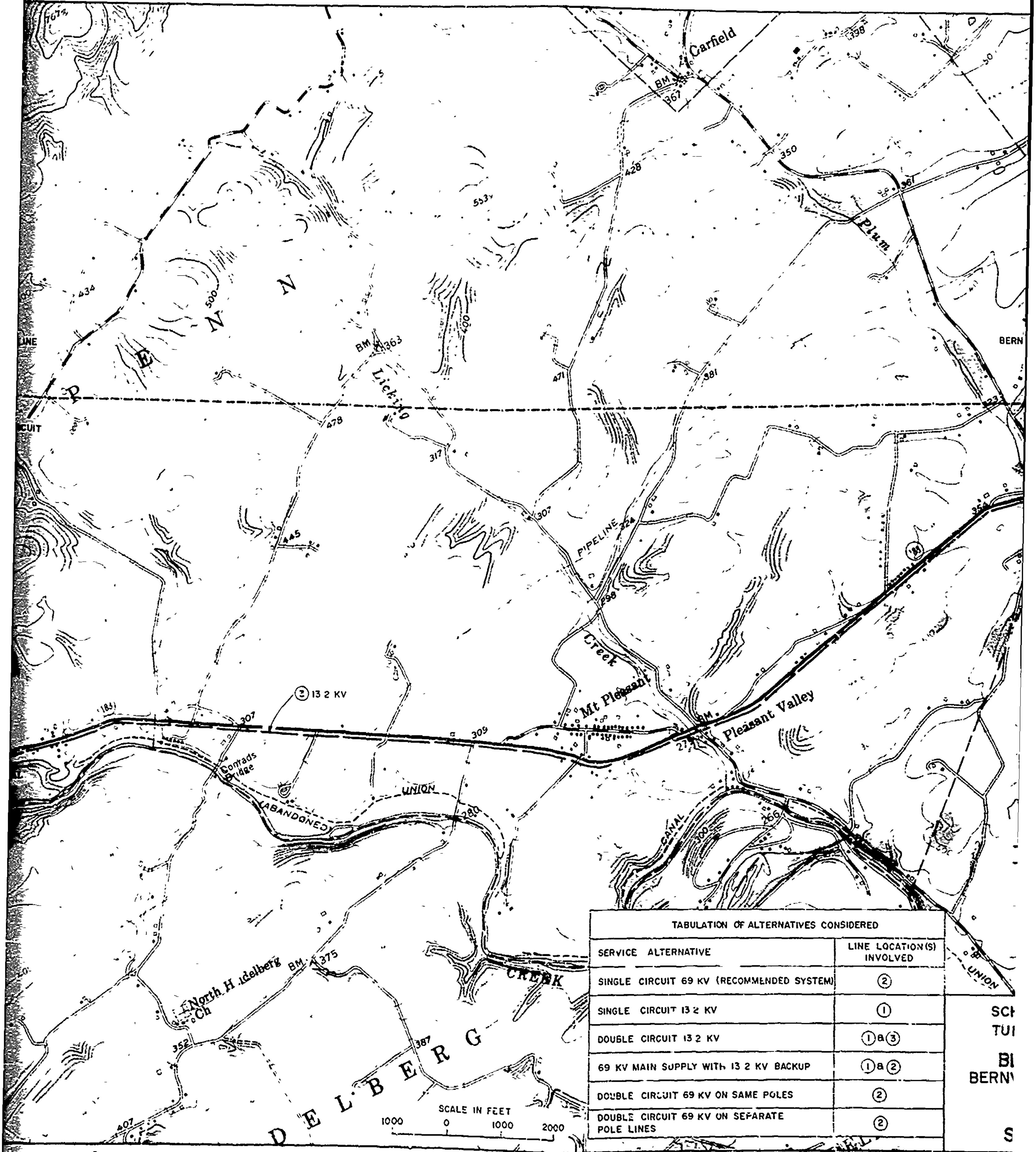


SECTION A-A

SCALE IN FEET
1 0 1 2 3 4 5 6 7

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
PUMPING STATION
DISCHARGE LINES


EXISTING 69 KV LINE
BERNVILLE SUBSTATION
EXISTING 13 2 KV LINE
FEEDING BERNVILLE
PUMPING PLANT
Bernville
BORO
BDY
EXISTING 69 KV LINE
Golf Course
Little Tulpehocken Ch
Little Northkill Creek
Stump Cem
UNION
CANAL
PIPELINE
Borrow Pits
Wagners Sch
JEFFERSON

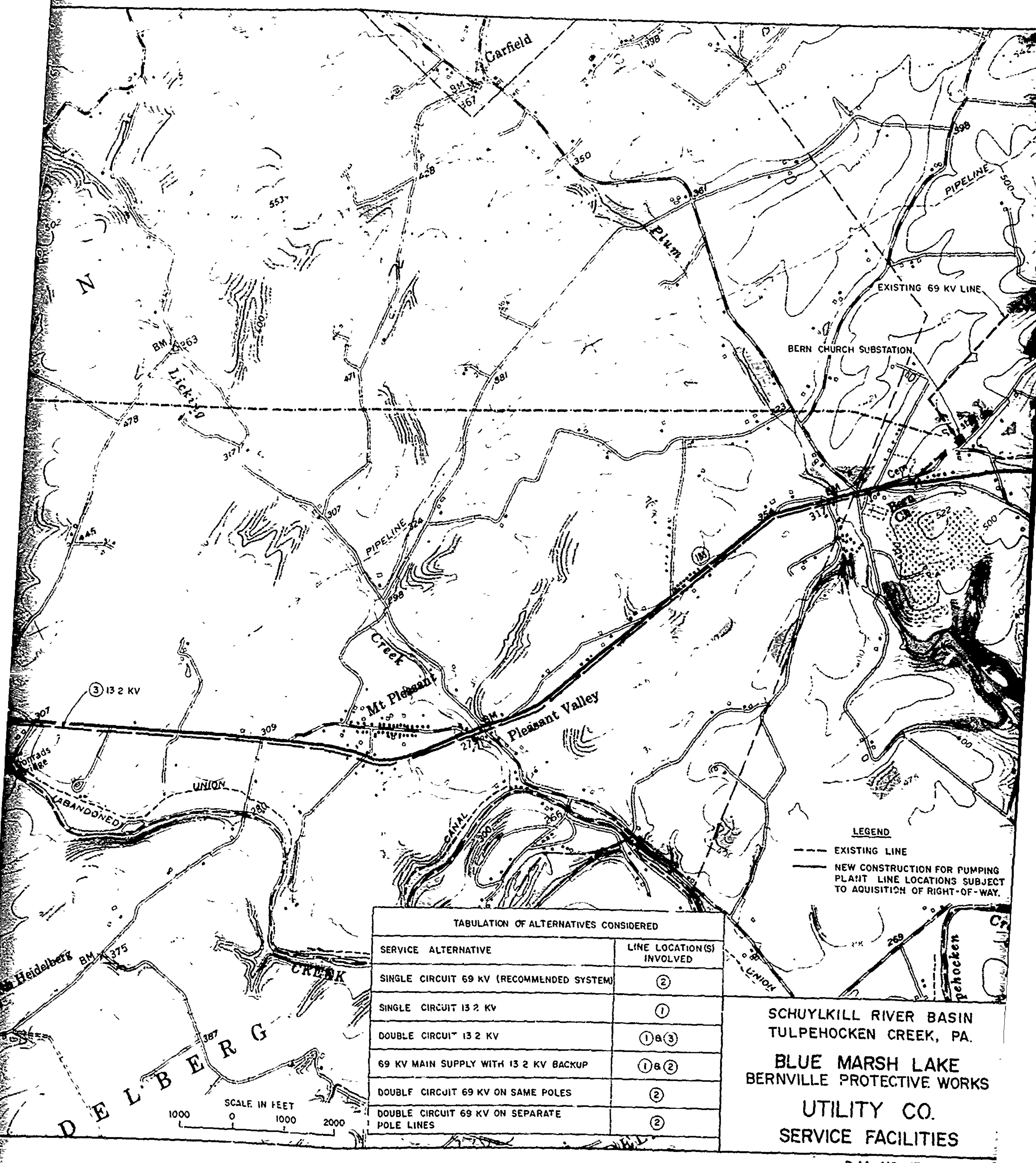


TABULATION OF ALTERNATIVES CONSIDERED

SERVICE ALTERNATIVE	LINE LOCATION(S) INVOLVED
SINGLE CIRCUIT 69 KV (RECOMMENDED SYSTEM)	②
SINGLE CIRCUIT 13 2 KV	①
DOUBLE CIRCUIT 13 2 KV	① a ③
69 KV MAIN SUPPLY WITH 13 2 KV BACKUP	① a ②
DOUBLE CIRCUIT 69 KV ON SAME POLES	②
DOUBLE CIRCUIT 69 KV ON SEPARATE POLE LINES	②

SCH
TUI
BI
BERN
S

2



TABULATION OF ALTERNATIVES CONSIDERED

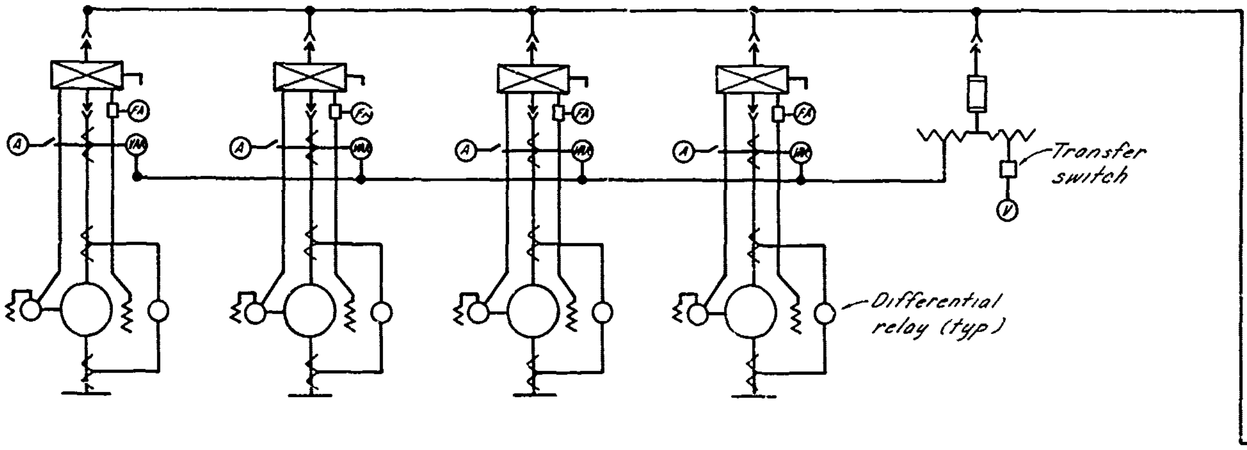
SERVICE ALTERNATIVE	LINE LOCATION(S) INVOLVED
SINGLE CIRCUIT 69 KV (RECOMMENDED SYSTEM)	②
SINGLE CIRCUIT 13 2 KV	①
DOUBLE CIRCUIT 13 2 KV	① & ③
69 KV MAIN SUPPLY WITH 13 2 KV BACKUP	① & ②
DOUBLE CIRCUIT 69 KV ON SAME POLES	②
DOUBLE CIRCUIT 69 KV ON SEPARATE POLE LINES	②

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

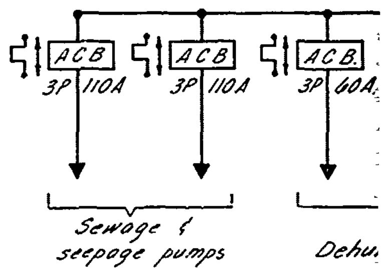
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

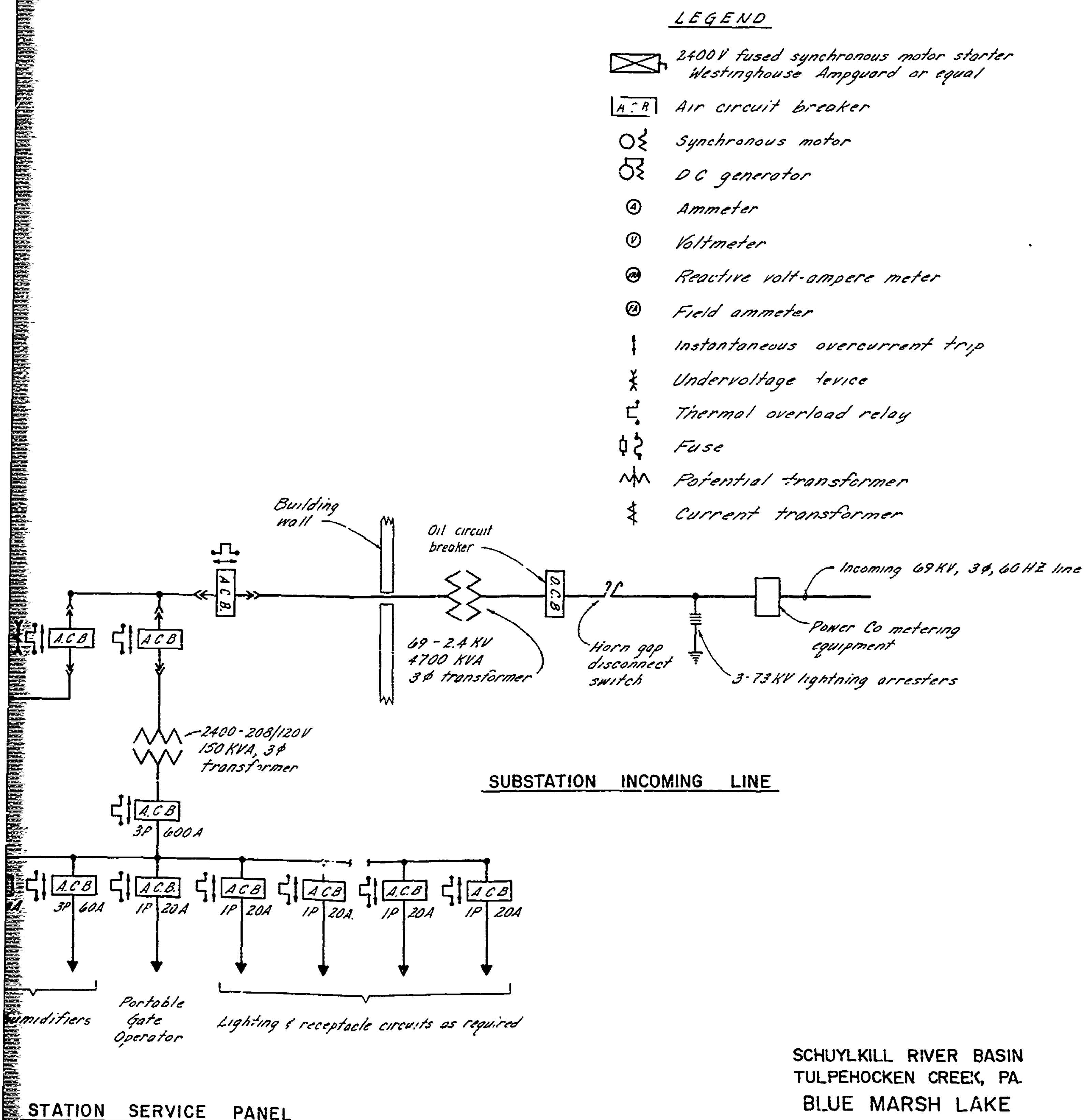
UTILITY CO.
SERVICE FACILITIES

D.M. NO. 13 PLATE



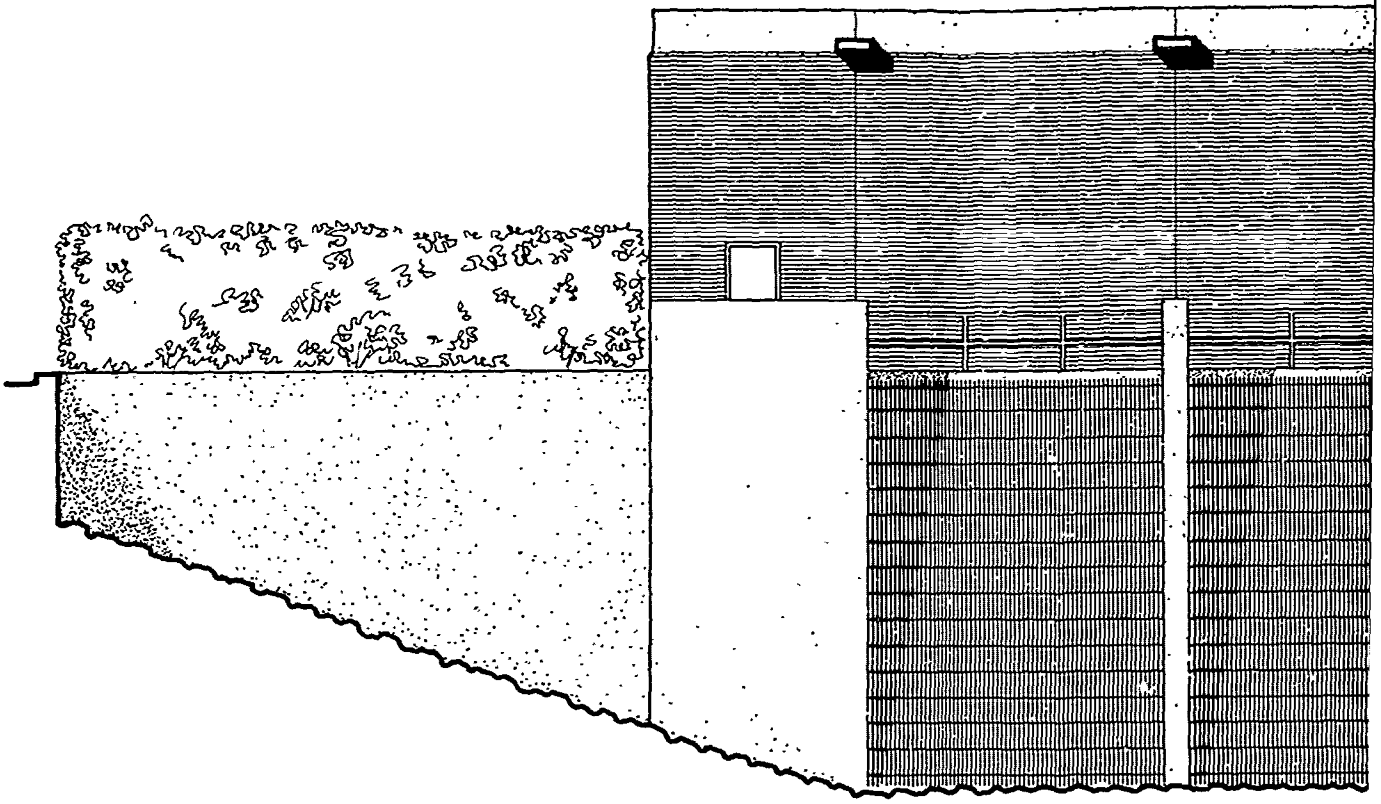
STORM WATER PUMPS



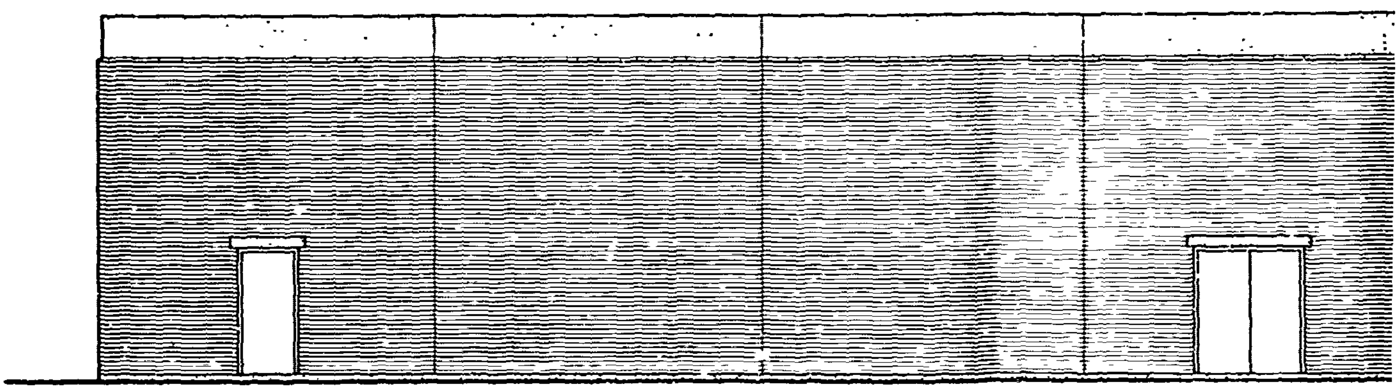


SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

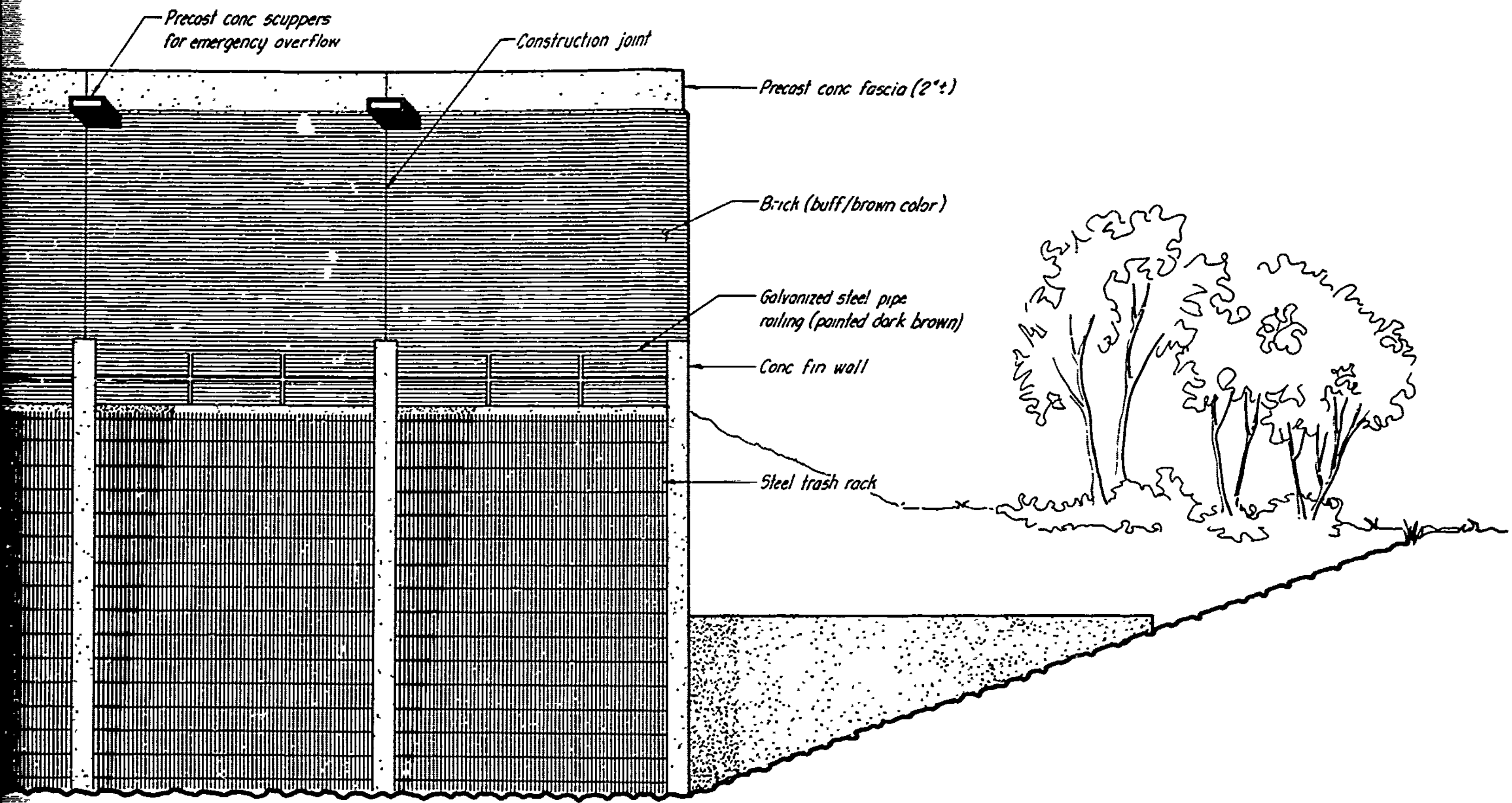
PUMPING STATION
ELECTRICAL ONE LINE DIAGRAM



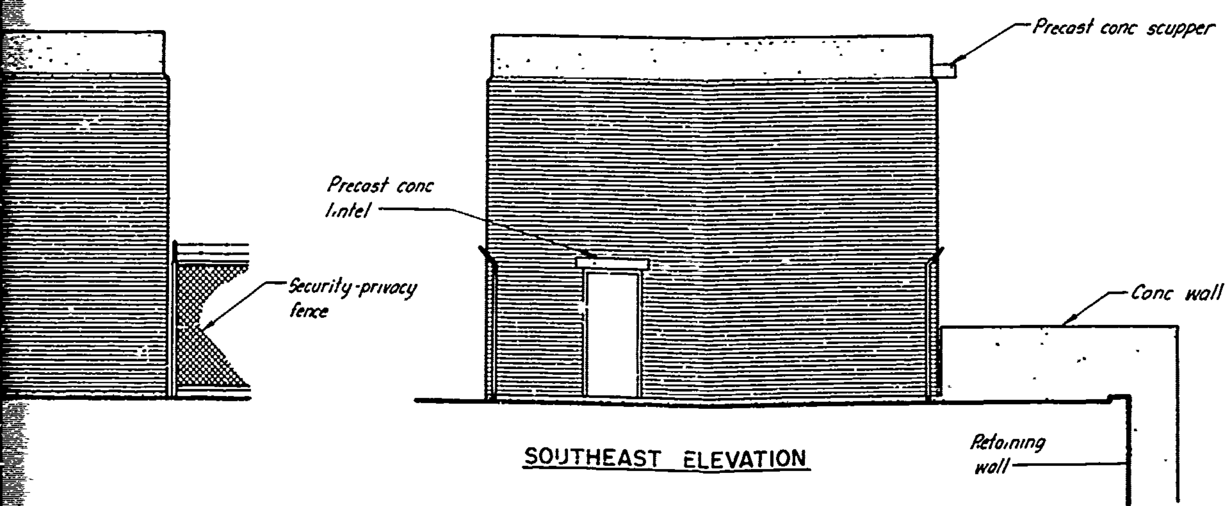
NC



SOUTHWEST ELEVATION



EAST ELEVATION



SOUTHEAST ELEVATION

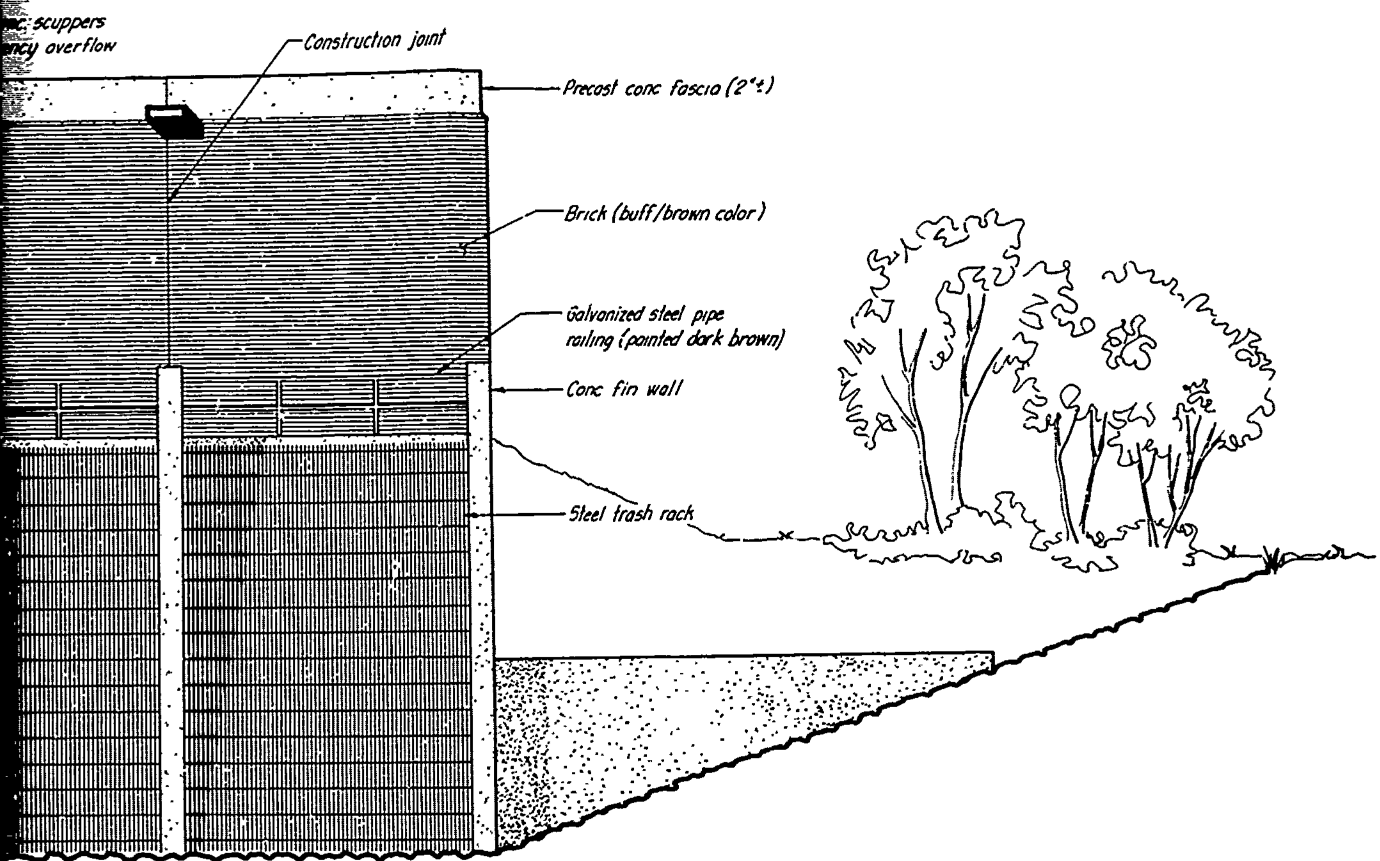
SCALE IN FEET
1 0 5 10 15

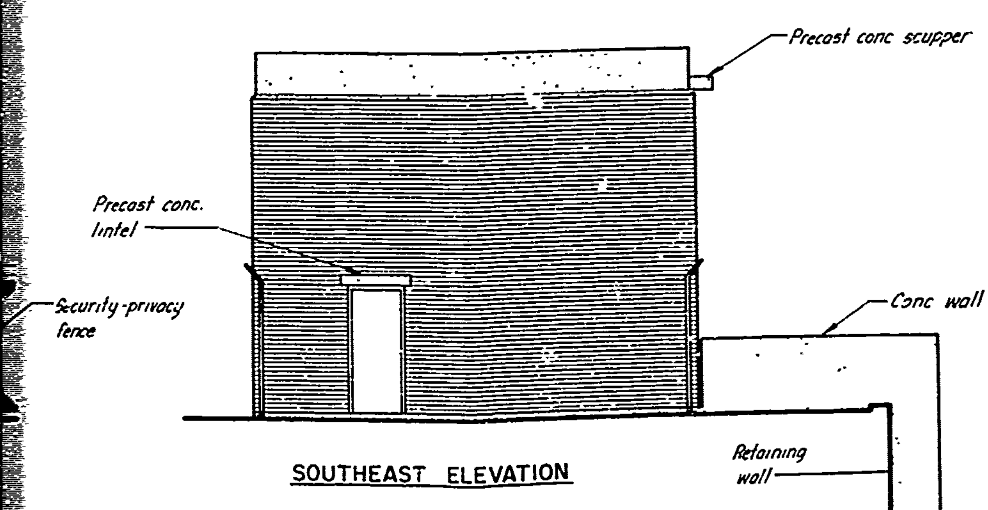
SCHUYLKILL RIVER BA
TULPEHOCKEN CREEK,
BLUE MARSH LA
BERNVILLE PROTECTIVE W

PUMPING STATI
ARCHITECTURA

U.M. NO.

2





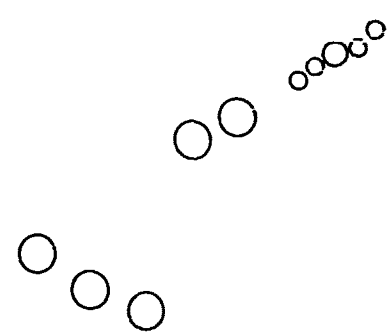
SOUTHEAST ELEVATION

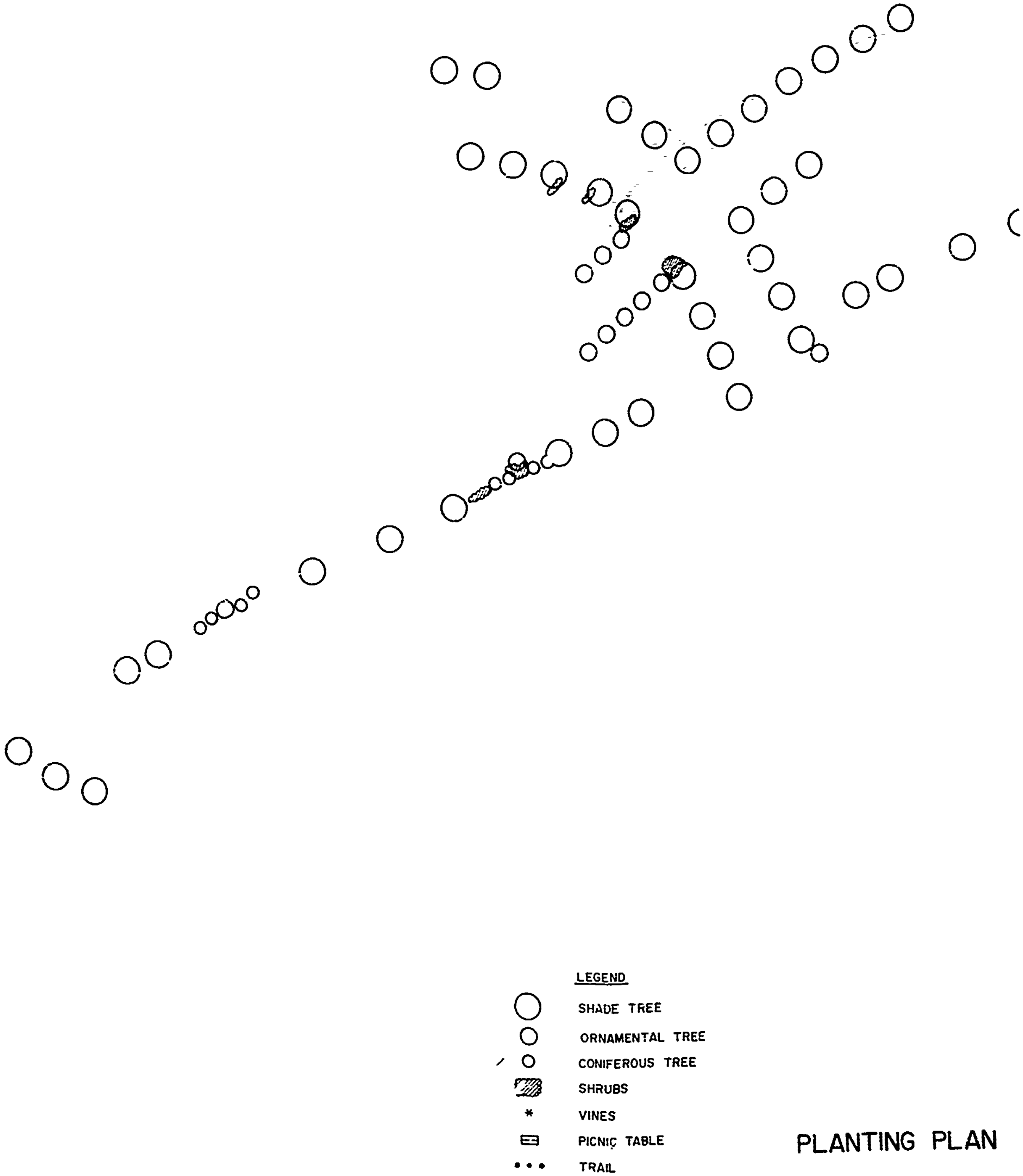
SCALE IN FEET
5 10 15

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

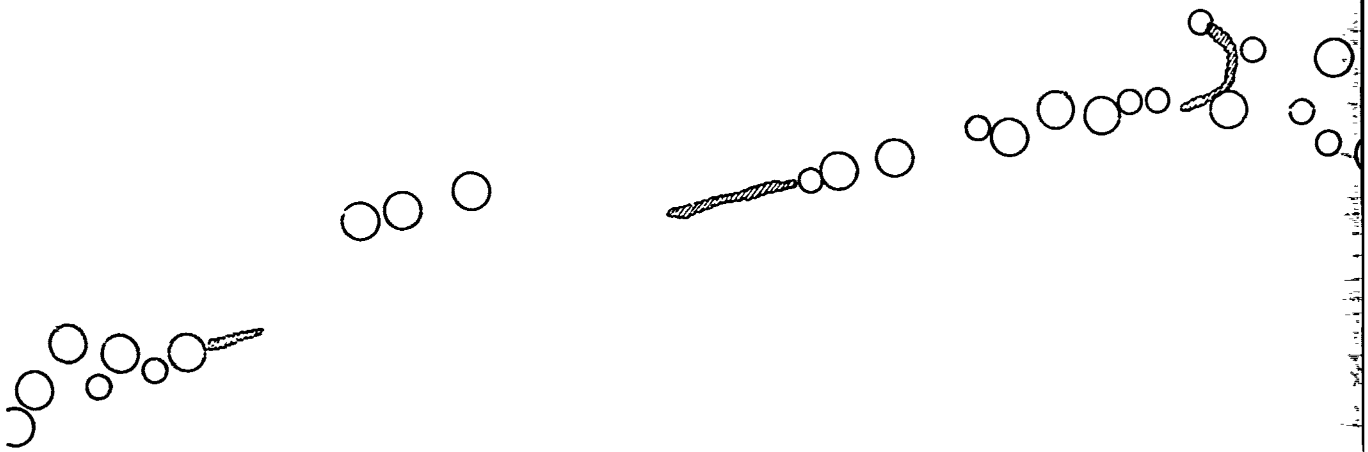
PUMPING STATION
ARCHITECTURAL

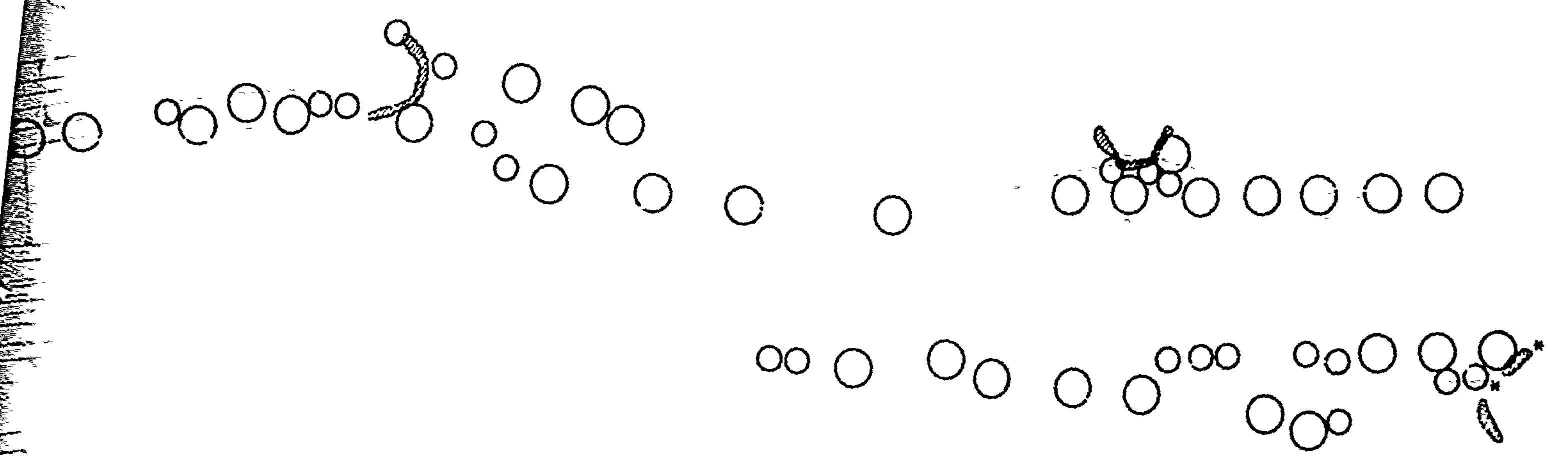
D.M. NO. 13 PLATE 27.3





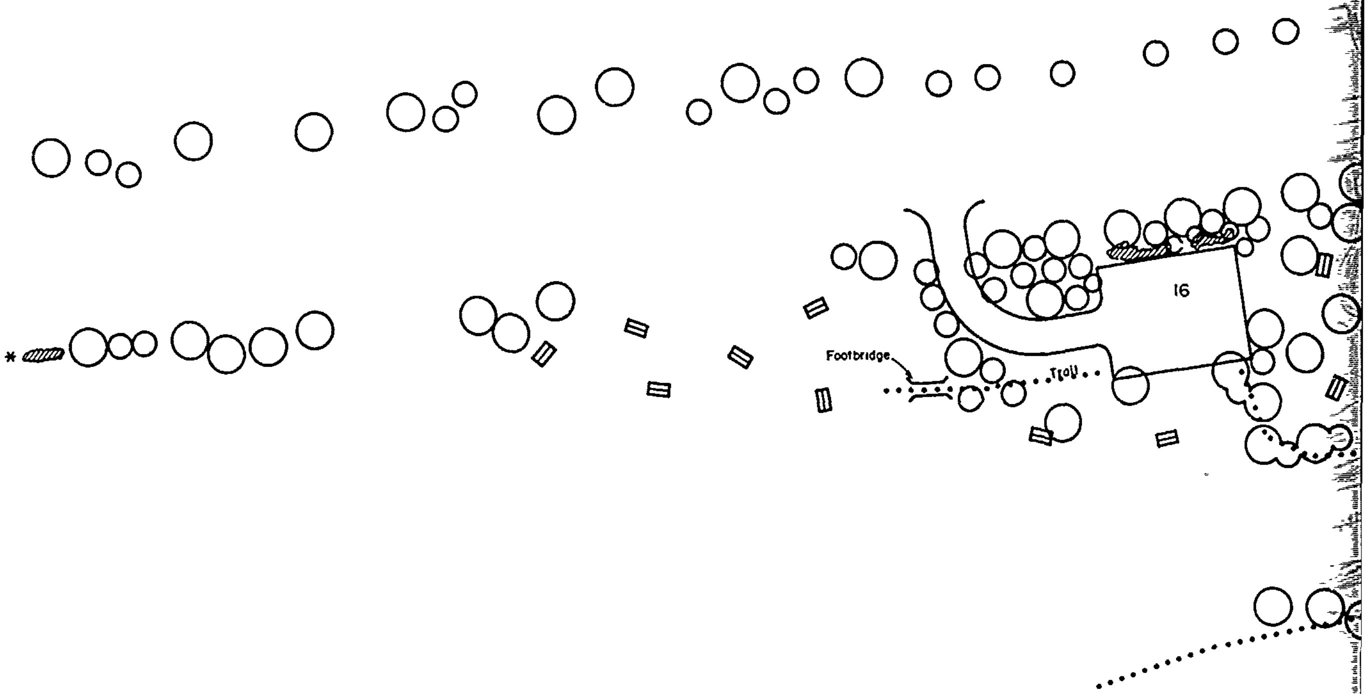
PLANTING PLAN



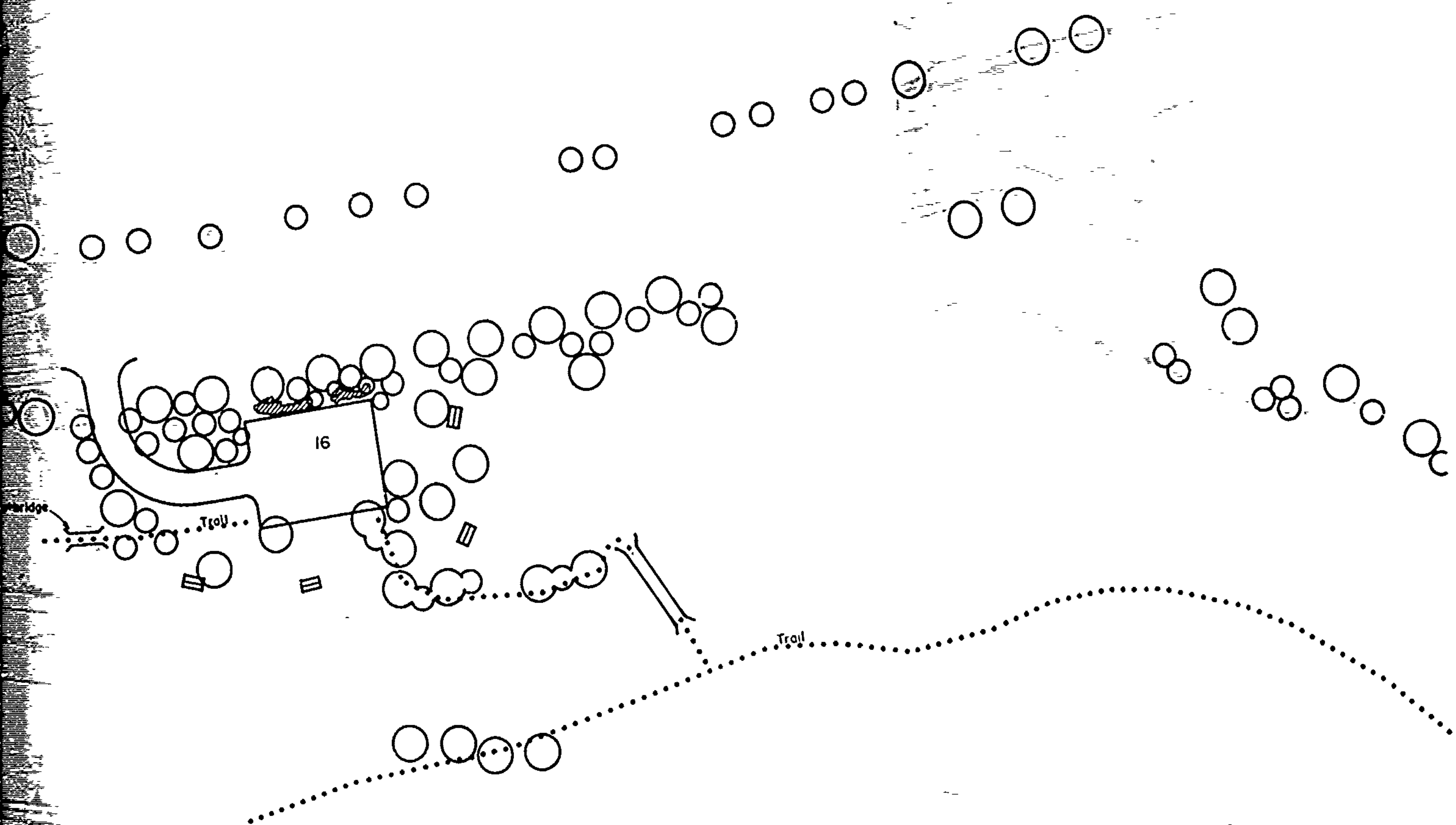


FOR LEGEND SEE PLATE 28

PLANTING PLAN

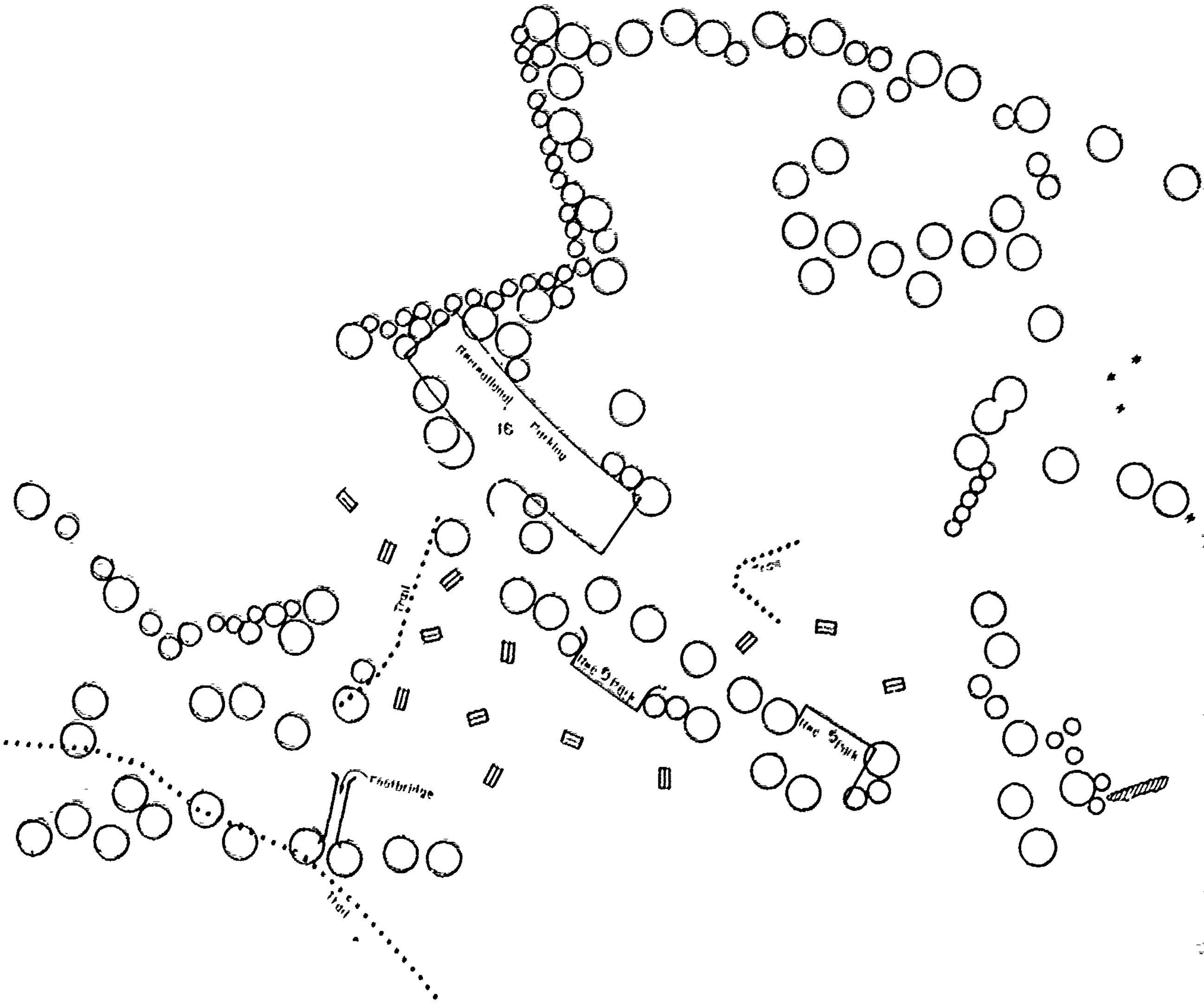


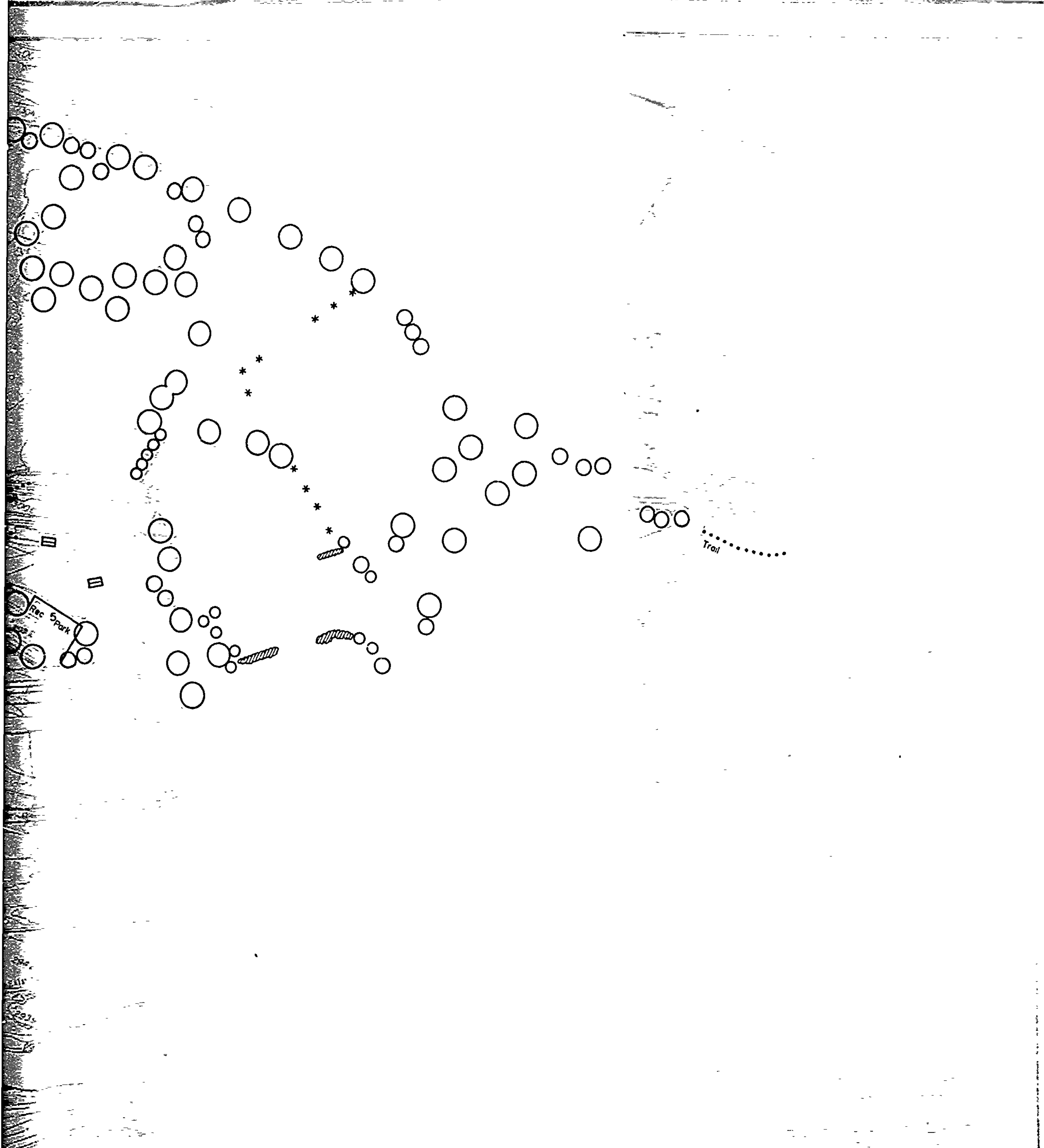
16
Footbridge
Trail
*



PLANTING PLAN

FOR LEGEND SEE PLATE 28

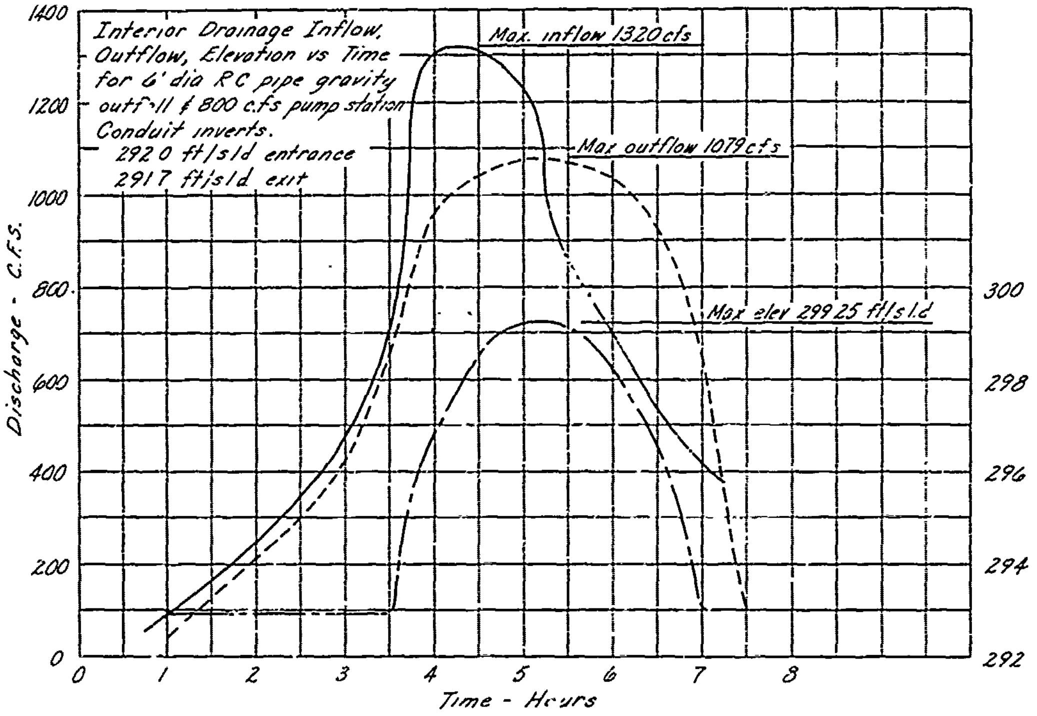

16
Parking
Trail
Footbridge
Trail

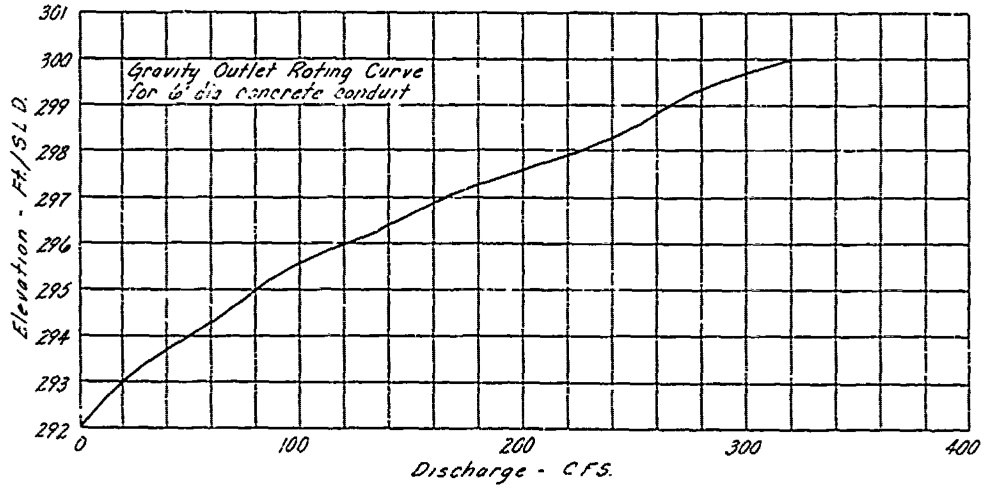


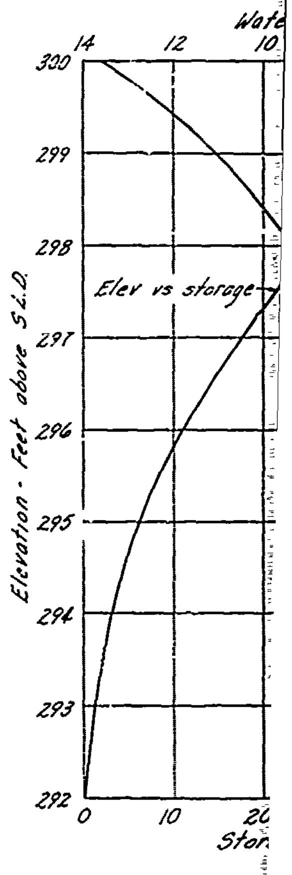
PLANTING PLAN

FOR LEGEND SEE PLATE 28

SURFACE ELEVATIO IN FEET	
ABOVE DEAD STORAGE LEVEL (2)	ABO MS
	2
0	29
1	29
2	29
3	29
4	29
5	2
6	2
7	2
8	3

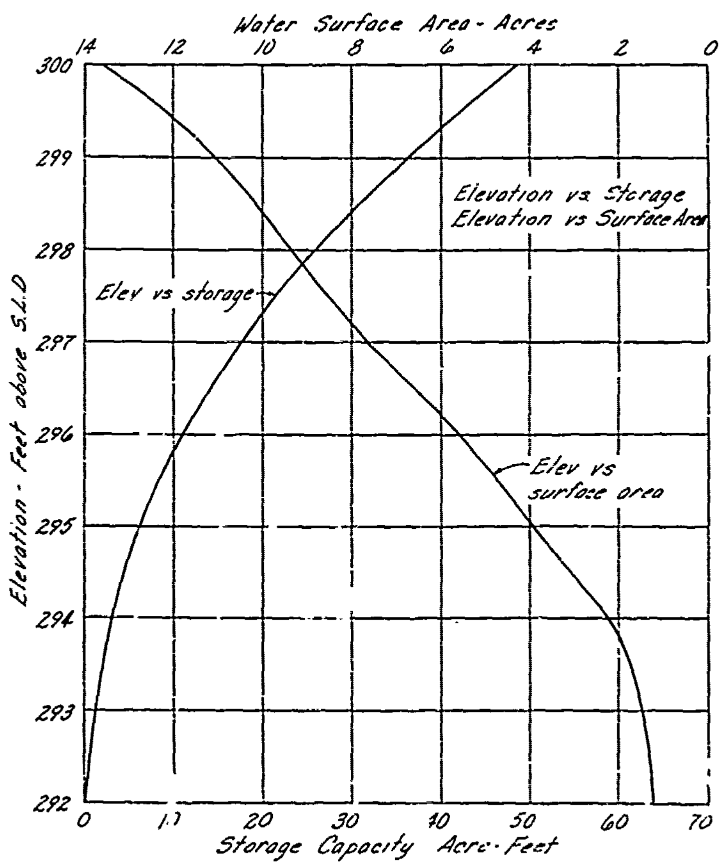






1

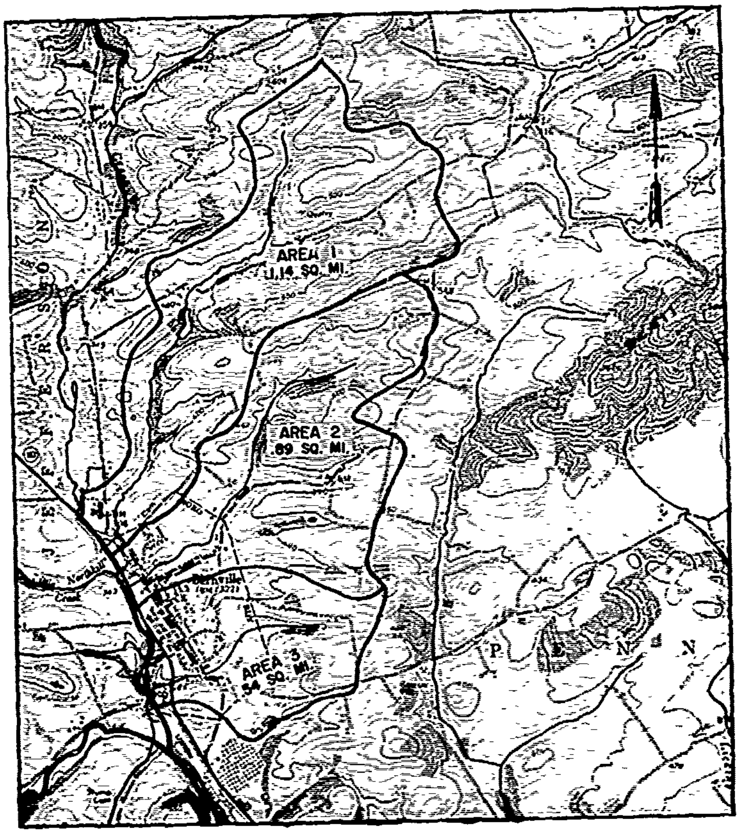
SURFACE ELEVATION IN FEET		SURFACE AREA, IN ACRES	NET STORAGE CAPACITY ABOVE (2) ELEVATION 292 IN ACRE FEET		(3) ACRES OF PONDING IN WHICH DEPTH EXCEEDS VALUE INDICATED IN COLUMN HEADINGS								STORAGE CAPACITY ABOVE ELEVATION 292 IN INCHES RUNOFF FROM DRAINAGE AREA
ABOVE DEAD STORAGE LEVEL (2)	ABOVE MSL		INCREMENTAL $\frac{(A_1 + A_2)\ D}{2}$	ACCUMULATIVE TOTAL	1'	2'	3'	4'	5'	6'	7'	8'	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	292	1 25											
1	293	1 48	1 36	1 36	1 25	0							00996
2	294	2 21	1 84	3 21	1 48	1 25	0						0235
3	295	3 95	3 08	6 29	2 21	1 48	1 25	0					0461
4	296	5 54	4 74	11 03	3 95	2 21	1 48	1 25	0				0808
5	297	7 65	6 59	17 63	5 54	3 95	2 21	1 48	1 25	0			1291
6	298	9 32	8 48	26 11	7 65	5 54	3 95	2 21	1 48	1 25	0		1912
7	299	11 03	10 17	36 29	9 32	7 65	5 54	3 95	2 21	1 48	1 25	0	2658
8	300	13 66	12 34	48 63	11 03	9 32	7 65	5 54	3 95	2 21	1 48	1 25	3562



SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

PONDING AREA AND
OUTLET WORKS
HYDRAULIC DATA



DRAINAGE AREAS

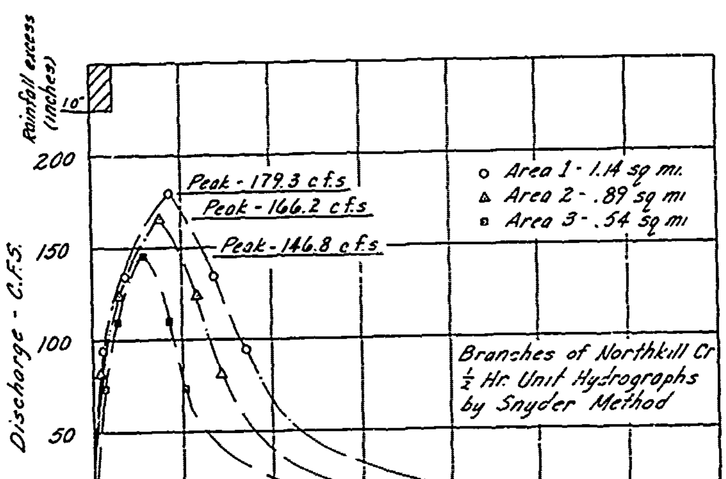
SCALE IN FEET

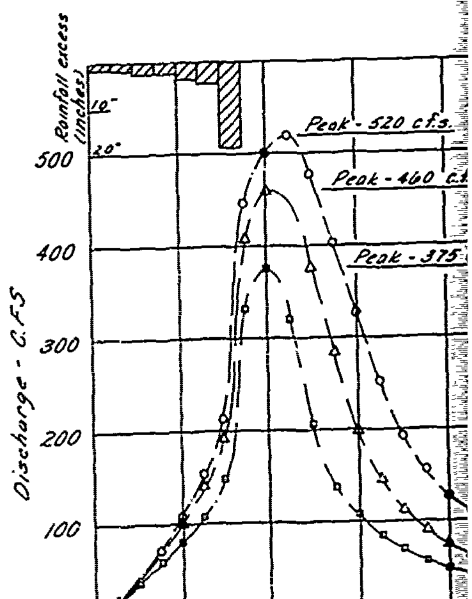
2000 0 2000 4000

RAINFALL DURATION IN HOURS
0.5
1.0
2.0
3.0
6.0
12.0
24.0
48.0

1) DATA TA

2) VALUES S
BE APPLI
WITHOUT



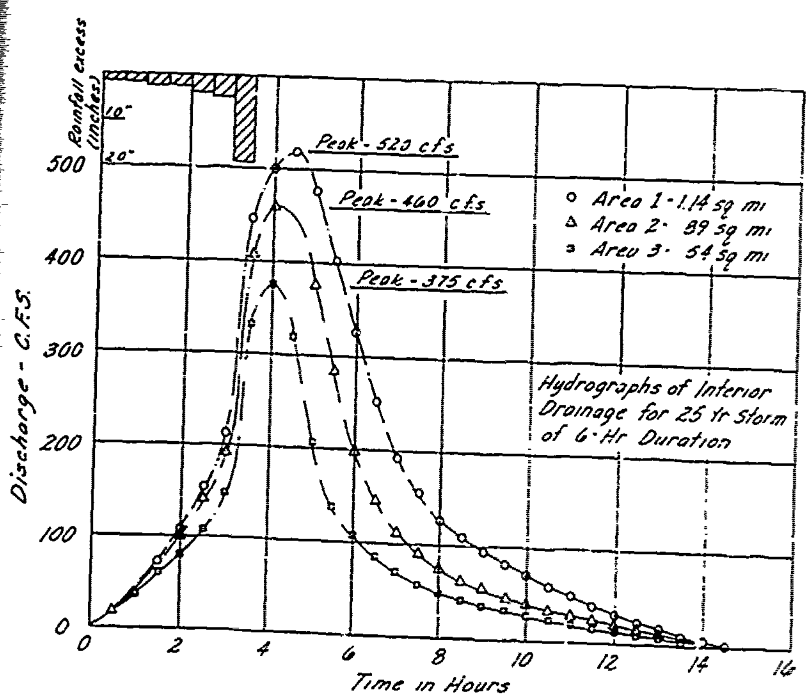


POINT PRECIPITATION DATA FOR BERNVILLE PA

RAINFALL DURATION IN HOURS	RAINFALL IN INCHES DEPTH CORRESPONDING TO VARIOUS AVERAGE FREQUENCIES AND DURATIONS IN HOURS						
	AVG EXCEEDED INTERVAL IN YEARS						
	1	2	5	10	25	50	100
0 5	90	1 09	1 43	1 55	1 86	2 10	2 35
1 0	1 12	1 42	1 71	2 05	2 34	2 63	2 91
2 0	1 42	1 72	2 16	2 56	2 90	3 28	3 70
3 0	1 56	1 92	2 40	2 85	3 30	3 69	3 90
6 0	1 92	2 26	2 94	3 35	4 08	4 38	4 50
12 0	2 16	2 75	3 48	4 08	4 80	5 28	5 88
24 0	2 40	3 12	4 08	4 80	5 28	6 00	6 72
48 0	-	3 84	4 32	5 28	6 24	7 20	8 09

1) DATA TAKEN FROM ISOHYETAL MAPS CONTAINED IN TECH PAPERS 40 & 49

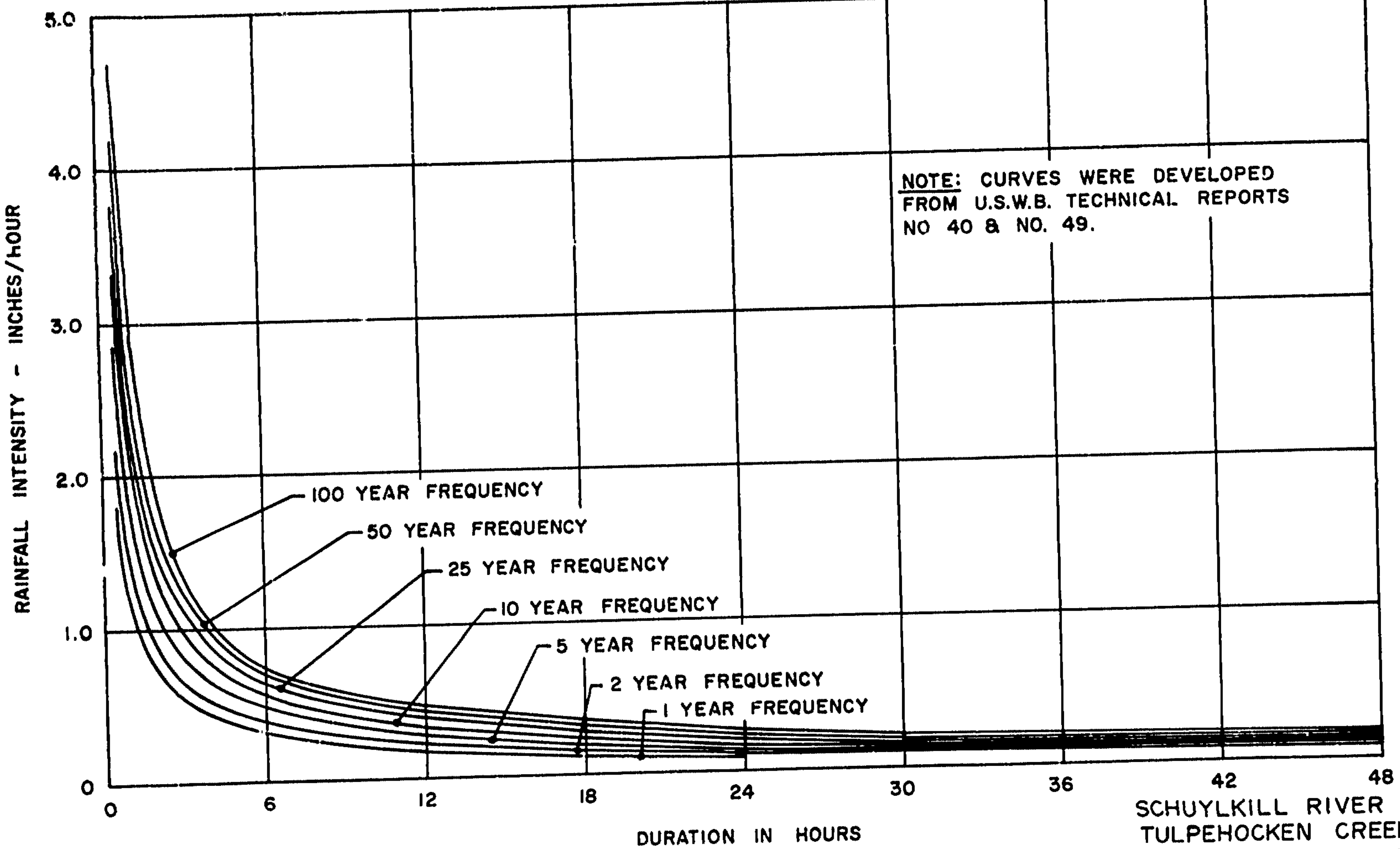
2) VALUES SHOWN ARE POINT VALUES AT BERNVILLE PA BUT ARE ASSUMED TO BE APPLICABLE TO THE INTERIOR DRAINAGE AREA (APPROX 2 57 SQ MI) WITHOUT ADJUSTMENT FOR BASIN SIZE



SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

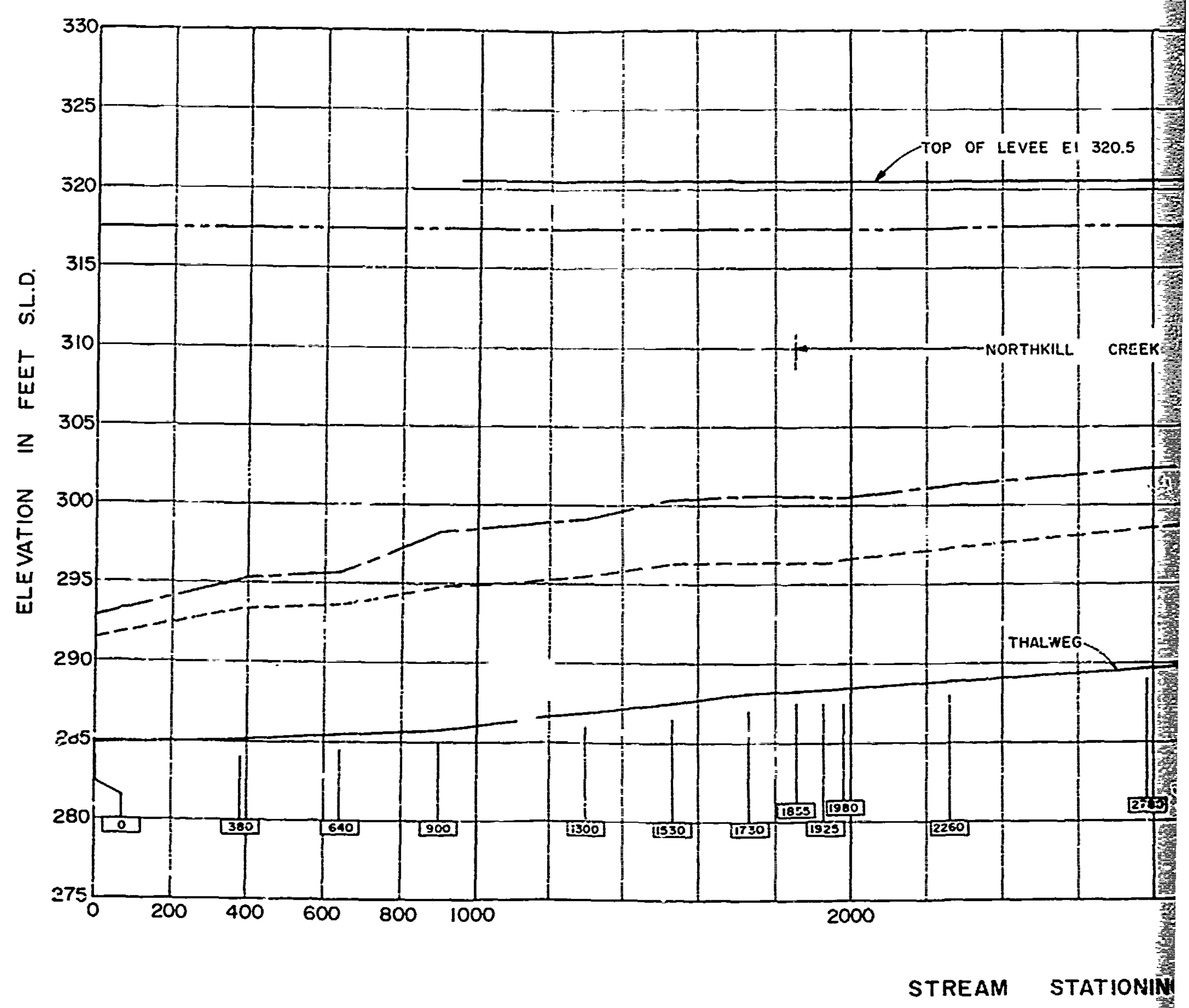
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

INTERIOR DRAINAGE
HYDROLOGY



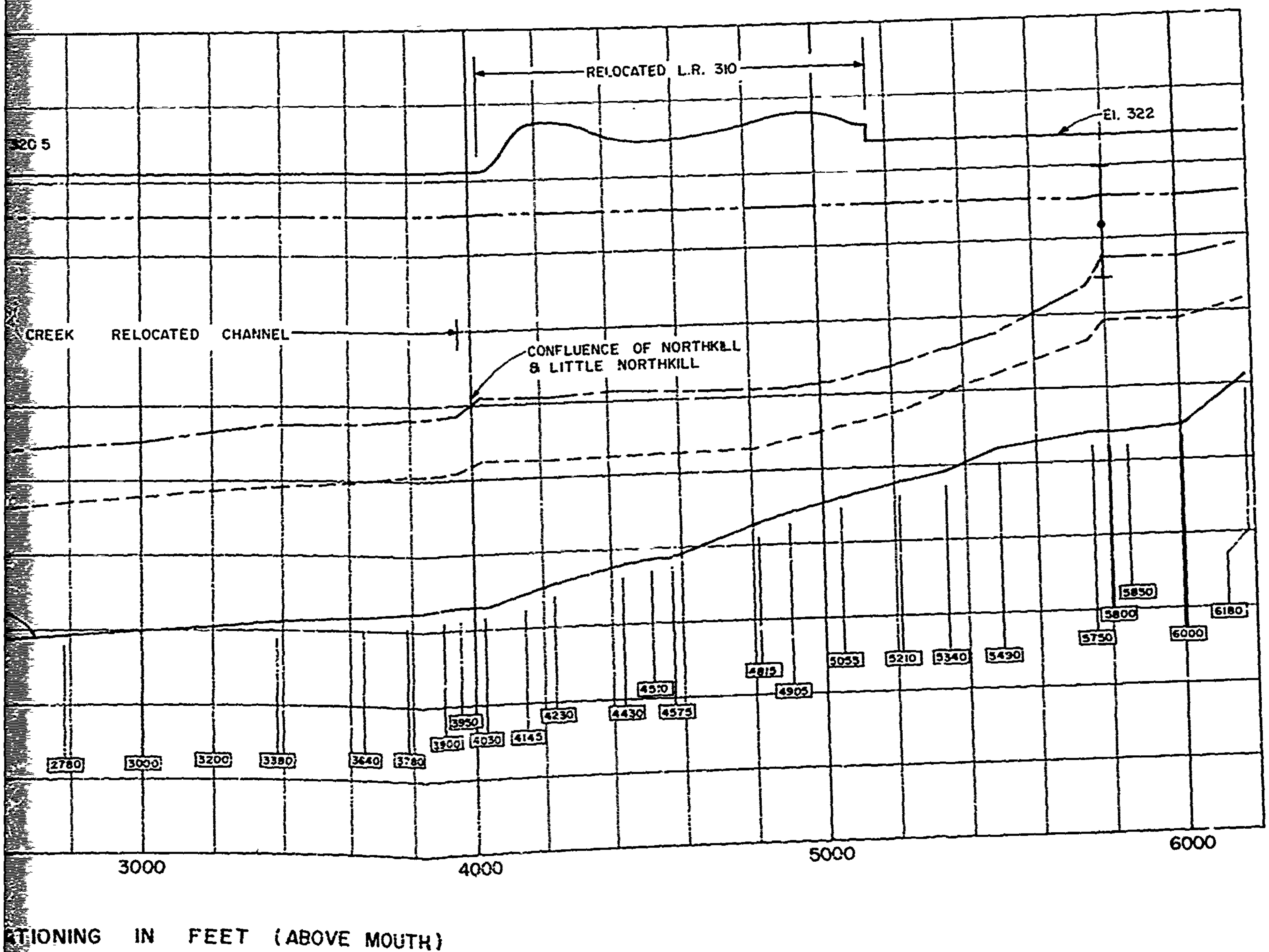
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

RAINFALL INTENSITY
DURATION CURVES



TOP OF LEVEE El 320.5
NORTHKILL CREEK
THALWEG
ELEVATION IN FEET S.L.D.
330
325
320
315
310
305
300
295
290
285
280
275
0
380
640
900
1300
1530
1730
1855
1925
1980
2260
0
200
400
600
800
1000
2000
STREAM STATIONIN

1



LEGEND

3000 CROSS SECTION

BRIDGE

MAXIMUM SPF ELEVATION

100 YR. ELEVATION

50 YR. ELEVATION PENN. D.O.T.

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE

BERNVILLE PROTECTIVE WORKS

WATER SURFACE PROFILE

DAM AND LEVEE IN PLACE

D.M. NO. 13 PLATE 35

2

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PENNSYLVANIA
BLUE MARSH LAKE

DESIGN MEMORANDUM NO. 13
BERNVILLE PROTECTIVE WORKS

APPENDIX A
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APPENDIX A

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SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PENNSYLVANIA
BLUE MARSH LAKE

DESIGN MEMORANDUM NO. 13
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APPENDIX A
SUBSURFACE EXPLORATIONS AND LABORATORY TESTING

SECTION 1

SUBSURFACE EXPLORATIONS

A-1-01. GENERAL. The subsurface explorations for Bernville Protective Works were performed in three phases. Phase one was conducted in April-May 1966 and has been covered in General Design Memorandum No. 4, Appendix III. The additional exploration phases were completed to establish engineering properties of the overburden and bedrock in the foundation of the proposed structures, to determine usage of materials from required excavations and to establish suitability of materials in the borrow areas. Phase two explorations were performed during October through mid-November of 1973 and consisted of 16 borings and 12 test trenches and included undisturbed sampling in borings SAB-21,23 and 25. Phase three included 9 borings which were drilled during October 1974. The locations of the borings and test trenches are shown on plate 4 and logs are presented on plates A-1 through A-4. The total drilled footage in the three phases for the 33 borings was approximately 700 feet and consisted of 338 feet in overburden and 362 feet in rock. Test trenches were excavated with a backhoe to depths ranging from 3 to 20 feet and generally averaged 8 to 12 feet in depth. The total vertical footage obtained in the trenches was approximately 210 feet and consisted of 115 feet in overburden and 95 feet in weathered rock.

A-1-02. SAMPLING. Overburden samples were continuously taken in the borings with $3\frac{1}{2}$" O.D., split-spoon samplers. Five undisturbed samples were recovered in the alluvial clays using 5-inch-diameter Shelby tubes. Large, bag samples of overburden and weathered rock were recovered from the test trenches for laboratory testing of representative materials from required creek excavations and the borrow areas. Samples of both weathered and unweathered bedrock were secured by NX coring in the borings.

SECTION 2

LABORATORY TESTING

A-2-01. GENERAL. A representative cross section of samples were selected for testing at New England Division Laboratory based on visual field classification. Preliminary testing consisted of mechanical analysis, Atterberg limits, and moisture content determinations. Based on the preliminary tests results, samples considered typical of the significant soil groups were selected for further detailed testing that consisted of direct shear, triaxial compression, permeability, and standard compaction tests.

A-2-02. FOUNDATION MATERIALS. The overburden soils in the levee foundation range from sandy silts and clays of medium to high plasticity to sandy gravels with trace of silt and clay. The softer, more plastic silts and clays located in the upper flood plain layer and reflected on logs of borings SAB-5, 6, 17, 20, 21, 24 and 33 are represented by tests conducted on undisturbed sample U-1 from boring SAB-21U. The stiffer sandy silts and clays in the foundation are represented by undisturbed samples taken below 4 feet in borings SAB-21U, 23U and 25U. Granular soils located within the levee foundation just above bedrock and in the required creek excavation are represented by tests on samples from trenches SAT-10 and 11. Test results on the foundation soils are summarized on plate A-6.

A-2-03. IMPERVIOUS FILL. Soils from borrow areas containing more than 25 percent passing the 200-mesh sieve will be used for impervious fill. Typical of these soils which consist of lean clays and silty and clayey sands are samples from test trench SAT-17 of borrow area Bravo, and from test trenches SAT-19, 20 and 21 of borrow area Alpha. The residual limestone soils found in borrow area Alpha are considered the more desirable type of impervious fill. Laboratory test results for impervious fill are summarized on plate A-5 with individual test reports presented on plates A-7 through A-9.

A-2-04. RANDOM FILL. Materials to be used as random fill will consist of clayey and silty sandy gravels and sandy gravels from required excavation and the borrow areas. A wide range in permeability for the random fill is anticipated and, therefore, selective placement will be required with the less pervious random materials placed adjacent to the impervious core. The more pervious random soils with less than 10 percent fines will be required to be placed in a zone at the landside slope toe. Organic soils and fine grained soils removed in required excavations that are too wet for placement as levee fill will be wasted. Laboratory test results representing typical random materials which would include the granular materials from required creek excavation are summarized on

plates A-5 and A-6. Individual test reports are presented on plates A-10 and A-11.

A-2-05. ROCKFILL. No laboratory tests were conducted on rockfill materials because of the small 3,600-cubic-yard volume involved. Adopted design valves for rockfill are based on previous District experience with similar materials on the Beltzville and Blue Marsh projects.

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PENNSYLVANIA
BLUE MARSH LAKE

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APPENDIX B
STABILITY ANALYSIS

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PLATES

CORPS OF ENGINEERS

SAB-1
EL 293.4
17 May 66

A	B	C Wn	E
			▼ 17 May 66
2		115.4	Clay, soft, organic CH
3		32.0	Clay brn, some f-c grav size shale frags CL
14			
68		7.6	Shale brn, soft, hly wthrd Core Point (NXM)
50			SHALE yel brn, soft to mod hard, hly to ptly frag & wthrd, most fracts stained w/fe, mn & clay & dip 0-90°, clv dips 70° - 80°
83	1-3		
95	1-5		6' - 15.5' mod hard, ptly wthrd
82	1-4		15.5'-25.5' soft-mod hard, hly-ptly wthrd & frag
53			NOTE: boring located in middle of bog w/ground water @ surface
40			
30			
93	1-2.5		SHALE mod hard, ptly wthrd red w/grn beds dipping 60°, clv dips 45° - 60°
100	1-6		Bottom of hole @ 30'

SAB-2
EL 295.9
3 May 66

A	B	C Wn	E
2		38.0	Topsoil
3		22.3	CLAY yel brn, moist, silty ▼ 3 May 66 CL
10		15.8	
24			GRAVEL c-f quartzite & shale frags, silty, cly GM-GC
37			
45			
18			SHALE red, mod hard, hly wthrd Core Point (NXM)
63			
	1-2		SHALE red, mod hard, hly-ptly frag & wthrd most fracts stained w/fe & mn & dip 35°-45° w/clv Some 30° - 40° opp clv, 12' - 30' ptly wthrd, mod hard - hard
100			
100	1-2		
73	1.5		
	4		
100	1.5		
	4		
100	1.5		
	7		
90	1.5		
	5		Bottom of hole @ 30.0'

SAB-3
EL 294.8
13 May 66

A	B	C Wn	E
5			▼ 13 May 66 Clay brn, silty moist, sdy CL
4		29.0	
7			SAND yel brn, cly, silty, m - f SC
16		15.2	
32		5.4	GRAVEL f - c, sandy, trace silt GP-GM
38			SHALE red, hly wthrd Core Point (NXM)
100	½-3		SHALE red, 5.5' - 6.0' hly-ptly frag & wthrd, soft-mod hard, 6.0' - 30.0', ptly wthrd, hly - ptly frag, mod hard, most fracts stained w/fe & mn & dip 35° - 50° w/clv, some opp to vertical
33			
75	½-3		
100			
86	2-5		
100	2-9		
60	1-2		
60	1-3		
100			
60	1-1.5		
65	1-2		
83	1-3		
66			Bottom of hole @ 30'

SAB-7
EL 311.7
25 Apr 66

A	B	C Wn	E
13			GRAVEL road fill, c-f shale & limestone fragments GP
25			NOTE: boring located on shoulder of road embankment adjacent to stream & crossing flood plain
28		3.1	
16			
18			
12			
15			
12			▼ 25 Apr 66
13			Top of Natural Ground
15		20.8	SAND brn, mf, silty clayey, some root mtl., 10' - 14' no samp, wash shows fine sand SM-SC
18			
17			
22			
35			
Reamed			GRAVEL c-f, w/cobbles & boulders, some silty sand Core Point (NXM) GM
100	½-3		SHALE sdy, grey & dark grey, soft-mod hard, ptly wthrd, hly-ptly frag, most fracts stained w/fe & dip 70° - 90° w/clv, numerous pyrite crystals
81	½-4		
90	1-2.5		
100	1-4.5		
100	1-3		Bottom of hole @ 25.3'

SAB-8
EL 307.4
4 May 66

A	B	C Wn	E
2			CLAY brn, silty, sdy, CL
4			▼ 4 May 66
4			SAND brn, c-f, silty, cly SC
11		11.3	SAND grey, c-f, silty, trace clay, some gravel, SM
12			
11			
8			
25			
36			SHALE grey & yellow brn, soft, hly wthrd, fracts filled w/cly silt, 14' - 15' thin beds hly wthrd limestone
37			
39			
68			
30			
58			
100		5.0	Core Point (NXM)
30	1-3		LIMESTONE - SHALE grey to dark grey limestone w/thin beds dark grey shale, mod hard-hard, ptly wthrd, hly-ptly frag, most fracts stained w/fe & mn & dip 40° w/beds, numerous laminae pyrite parallel beds, few fracts 40° - 50° opp beds, clv parallel to bedding
90	1-3		
100	½-1		
100	½-1		
90	1-6		
66	1-3		
80	½-2		Bottom of hole @ 25.0'

SAB-9
EL 313.2
1 Nov 73

A	B	C Wn	E
18			Topsoil
26		6.3	GRAVEL road fill consisting of c-f grav size shale & limestone fragments, sandy, trace silt
Reamed		3.2	GP-GM
Cored w/ NWM Barrel			hole caved @ 9.8' on completion, groundwater not recorded.
			Top Natural Ground
			COBBLE w/grey silt
			SHALE olive, soft, hly wthrd Core Point (NXM)
45	½-3		SHALE olive grey, mod hard, ptly wthrd, hly-ptly frag, most fracts dip 35° w/clv few vertical joints
100	1-4		Bottom of hole @ 20.5'

SAB-17
EL 298.9
1 Nov 73

A	B	C Wn	E
2			TOPSOIL
2			CLAY brn, sandy, silty, mottled w/grey
6		18.4	LL 28.1, PI 9.9
11			CL
21			▼ 1 Nov 73
20			
37		18.1	SAND dk brn, gravelly, silty cly SC
57			
63			SHALE brn, hly wthrd Core Point (NXM)
72/0.3'			
54			SHALE red, mod hard, ptly wthrd, hly-ptly fragmented, some of fragmentation due to grinding, most fractures dip 55° - 60° w/clv
100	1-5		Bottom of hole @ 17.3'

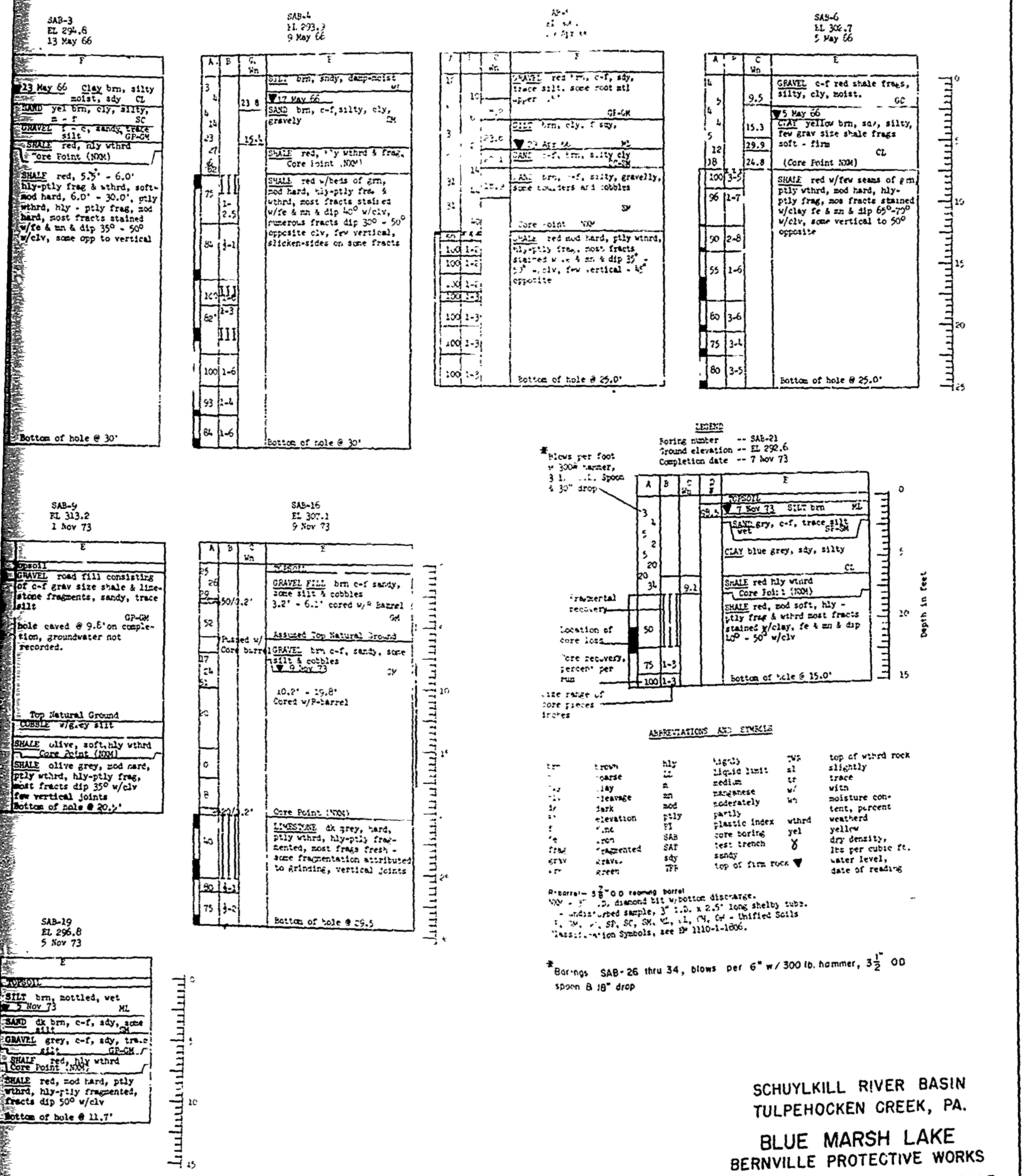
SAB-18
EL 298.2
3 Nov 73

A	B	C Wn	E
7			TOPSOIL
17			SILT brn, sdy, cly ML
25			
100		[illegible]	
Augered			GRAVEL brn, c-f, sdy, trace silt
47			▼ 3 Nov 73
Augered			GP-GM
22			
56		8.7	
66			
50@		5.4	SHALE red, hly wthrd Core Point (N-Barrel)
60			SHALE red, soft-mod hard, hly-ptly fragmented & wthrd, most fracts stained & dip 50° - 60° w/clv, 10' - 12.8', ptly wthrd & mod hard
50	½-2		Bottom of hole @ 12.8'

SAB-19
EL 296.8
5 Nov 73

A	B	C Wn	E
3			TOPSOIL
9			SILT brn, mottled, wet
11			▼ 5 Nov 73 ML
15		18.2	SAND dk brn, c-f, sdy, some silt SC
33			
76		10.4	GRAVEL grey, c-f, sdy, trace silt GP-GM
82/0.1			
Augered			
100			SHALE red, hly wthrd Core Point (NXM)
95	½-3		SHALE red, mod hard, ptly wthrd, hly-ptly fragmented, fracts dip 50° w/clv
			Bottom of hole @ 11.7'

U.S. ARMY



SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

LOGS OF EXPLORATIONS
STRUCTURES

D.M. NO. 13 PLATE A-1

CORPS OF ENGINEERS

SAB 20
EL 295.7
6 Nov 73

A	B	C Wn	E
			▼ 6 Nov 73
			TOPSOIL
2 2		21.1	SILT yel-brn, c-f sdy ML LL 26.4, PI 7.4
10 62			GRAVEL brn, c-f, some clay, sdy GC
Augered			
77	508	0.3'	SHALE red, hly wthrd Core Point (NXM)
100	½-4		SHALE red, mod hard, ptly wthrd, hly-ptly fragmented, most fracts stained & dip 30° - 35° w/clv
100	½-2		
			Bottom of hole @ 11.4

SAB-21
EL 292.6
7 Nov 73

A	B	C Wn	E
3			TOPSOIL
			▼ 7 Nov 73 SILT brn ML
4 5			SAND gry, c-f, trace silt wet SP-SM
2 5 20			CLAY blue grey, sdy, silty CL
20 34		0.1	SHALE red hly wthrd Core Point (NXM)
50			SHALE red, mod soft, hly - ptly frag & wthrd most fracts stained w/clay, fe & mn & dip 40° - 50° w/clv
75	1-3		
100	1-3		Bottom of hole @ 15.0'

SAB-23
EL 303.8
2 Nov 73

A	B	C Wn	E
			TOPSOIL
3 10 22		21.9	▼ 2 Nov 73 CLAY brn, sdy LL 39.0' PI 15.8 CL
41 61 47		17.5	SAND brn c-f, silty trace gravel SM
13 16 16 34			CLAY olive grn - gry brn, w/ thin layers f sand CH
21 22 22			SAND brn, c-f, gravelly, Some clay SC
26			SAND brn c-f, gravelly some silt SM
60 46 42 117			GRAVEL brn, c-f, sdy, some silt - silty, trace cobbles GM
64	50	@ 0.3'	Bottom of hole @ 19.3'

SAB-23 U
EL 304.3
15 Nov 73

A	B	C Wn	E
			▼15 Nov 73 Reamed 0-7' w/6" auger, 5'-11.5' Sampled w/5" Shelby sampler, U-1, U-2 & S-1 are undisturbed samples
U-1		20.4	CLAY grey, silty, trace fsd LL 38, PI 16
U-2		18.1	LL 33, PI 10 CL
S-1		Pushed	SAND c-f, cly. gravelly, SC Bottom of hole @ 11.5'

SAT-1
EL 294.0
11 May 66

C Wn	D γ	E
		TOPSOIL
		GRAVEL c-f angular-subangular shale fragments, some cobbles GP
	127.2	GRAVEL f, blue grey, cly GC
		▼11 May 66
		GRAVEL c-f shale frags, sdy, trace clay GP-GM
		GRAVEL c-f angular-sub angular shale & quartz frags, GP excavated w/ backhoe to shale bedrock to 10' @ North end & 20' @ South end-
		Bottom of trench 10'-20'

SAT-2
EL 291.6
12 May 66

C Wn	D γ	E
		TOPSOIL
	131.0	CLAY brn, sdy, soft, LL 31, PI 11 ▼12 May 66 CL
	145.0	GRAVEL c-f, subangular shale frags, some grey clay GC
		GRAVEL c-f shale & quartz frags, some C-F sand, few cobbles & Boulders GP
		SHALE red, hly-ptly wthrd, soft-mod hard, excavated w/ backhoe
		Bottom of trench @ 9.0'

SAT-3
EL 296.9
6 May 66

C Wn	D γ	E
		TOPSOIL
	103.4	CLAY brn, f sdy, soft LL 29, PI 10 CL
		▼6 May 66
		SAND c-f, c-f gravelly Silty SM
		GRAVEL c-f subangular - rounded shale & sand stone frags, some cobbles & c-f sand, could not dewater below 6.0' w/ pump rated @ 50 gpm
		SHALE red brn, hly-ptly wthrd soft-mod hard, excavated w/ backhoe
		Bottom of trench @ 12.0'

U.S. ARMY

(partial log, left edge)

SILT brn ML
..., trace silt SP-SM
..., sdy, silty CL
... wthrd (NXM)
... soft, hly - ...rd most fracts ... fe & mn & dip
... @ 15.0'

SAB-21U
EL 292.6
15 Nov 73

A	B	C Wn	E
			Reamed 0-2' w/6" auger ▼11/15/73 U-1 & U-2 are 5" shelby samples
U-1		45.1	CLAY blue grey, trace f sd LL 63 PI 33 CH
U-2		22.7	CLAY red, sdy, LL 42, PI 19 5' - 6' gravelly CL Bottom of hole @ 6.0'

SAB-22
EL 319.7
8 Nov 73

A	B	C Wn	E
			TOPSOIL
26 62			GRAVEL brn, c-f, cly GC
Augered		4.9	GRAVEL brn c-f, sdy, some silt GM
180			Core Point (NXM)
100	1-6		SHALE olive grn, ptly wthrd, mod hard, hly-ptly fragmented, 7.5' - 8.3' hly wthrd, most fracts stained w/fe & mn & dip 40° - 50° w/clv, some 50° opp.
80	1-3		Groundwater not encountered.
60	1-4		
90			Bottom of hole @ 12.7

0 5 10 15

(partial log, left edge)

...6" auger, ...ed w/5" ... U-1, U-2 & S-1 ... samples
... silty, trace fsd CL
...y, gravelly, SC
... hole @ 11.5'

SAB-24
EL 303.3
15 Nov 73

A	B	C Wn	E
			TOPSOIL
5 2			SILT brn, c-f sdy
2 2 3			▼ 15 Nov 73 ML
Augered			SAND brn, c-f, c-f gravelly, some clay SC
42 69 70 22			
16 32 7 20			GRAVEL brn c-f, c-f sdy, silty GM Bottom of hole @ 13.0'

SAB-25
EL 304.7
16 Nov 73

	A	B	C Wn	E
				TOPSOIL
4 5				GRAVEL brn c-f sdy, some clay GC
9 13 9 8 8 6	U-1, 5" shelby sample			SAND brn c-f, some silt - silty, gravelly, groundwater not encountered SM
			16.8	CLAY brn, c-f sdy, some gravel CL
U-1	20	0.1'		SHALE red, hly wthrd Bottom of hole @ 8.5'

0 5 10 15

SAT-3
EL 296.9
6 May 66

E
TOPSOIL
CLAY brn, f sdy, soft LL 29, PI 10 CL
▼6 May 66
SAND c-f, c-f gravelly Silty SM
GRAVEL c-f subangular - rounded shale & sand stone frags, some cobbles & c-f sand, could not dewater below 6.0' w/ pump rated @ 50 gpm
SHALE red brn, hly-ptly wthrd soft-mod hard, excavated w/ backhoe Bottom of trench @ 12.0'

SAT-4
EL 403.4
10 May 66

C Wn	D γ	E
		TOPSOIL
		GRAVEL brn, c-f angular-sub-angular shale frags GP
	122.7	Groundwater not encountered. excavated w/ backhoe
		SHALE grn-grey, hly-ptly wthrd, soft-mod hard, bedstrike N-S & dip 40° W Bottom of trench @ 10.0'

SAT-10
EL 298.5
14 Nov 74

C Wn	D γ	E
		TOPSOIL
		SAND brn, c-f, trace silt & cobbles SP-SM
		SAND brn, c-f, some silty clay, gravelly SM-SC
		SAND brn, c-f, trace silt, gravelly SP-SM
		SHALE red, soft-mod hard, hly-ptly wthrd, ground water not encountered, excavated w/ backhoe Bottom of trench @ 8.8'

SAT-11
EL 296.6
14 Nov 73

C Wn	D γ	E
		▼14 Nov 73 TOPSOIL
		CLAY mottled grn & brn, mod stiff, trace f sand, LL 80, PI 46 CH
		SHALE olive grn, sdy, hly-ptly wthrd, soft-mod hard, excavated w/ backhoe Bottom of trench @ 8.7'

0 5 10 15

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

LOGS OF EXPLORATIONS
STRUCTURES

For abbreviations and symbols see plate A-1

D.M. NO. 13 PLATE A-2

SAB-26
EL 314.0
2 Oct. 74

A	B	C	D
3 9 1			TOPSOIL
			SAND br c-f silty, cinders & root material (fill) SM
Reamed			
30 50 .0'			CLAY brn, silty, c-f sdy Core Point (NX)
100			SHALE red, hly-ptly wthrd & frag & soft - mod hard to 13', clv 60° - vertical
100			2 Oct 74
86	½-1		13'-30', mod hard, ptly - slightly wthrd & frag, most fracts stained w/fe & mn & dip 50° - 60° w/clv, few 20° opposite
100	1-4		
100	1-5		
100	1-5		
100	1-6		
100	1-6		Bottom of hole @ 30.0'

SAB-27
EL 303.5
2 Oct. 74

A	B	C	E
3 6 9			SAND brn, silty c-f w/ trace gravel to 1" SW
Reamed			CLAY brn, f sdy, tr grav to 1"
16 50/0.1'			
Reamed			3 Oct 74 SHALE hly wthrd Core Point (NX)
100	½-1		SHALE red mod hard, hly-ptly wthrd & fragmented to 9.2'
100	½-1		9.2'-19' hard, ptly wthrd, most fractures stained w/ fe & mn & dip 40°-55° w/ clv, few 20° opposite clv
100	1-2		
96	1-3		Bottom of hole @ 19.2'

SAB-28
EL 30[illegible]
3 Oct. 74

A	B	C	E
5 4 3			TOPSOIL
			CLAY brn, c-f sdy, some grav - 2" CL
Reamed			
14 9 4			SAND brn, c-f, few pieces grav - 3"
3 3 4			7 Oct 74 SM
Reamed			
6 23 14			SILT brn, cly, wet ML
Reamed			SHALE red hly wthrd Core Point (NX)
100	½-4		SHALE red, mod hard, ptly wthrd & frag, fracts dip 35°-70° w/ clv
100	1-5		Bottom of hole @ 1[illegible]'

SAB-31
EL 297.0
7 Oct. 74

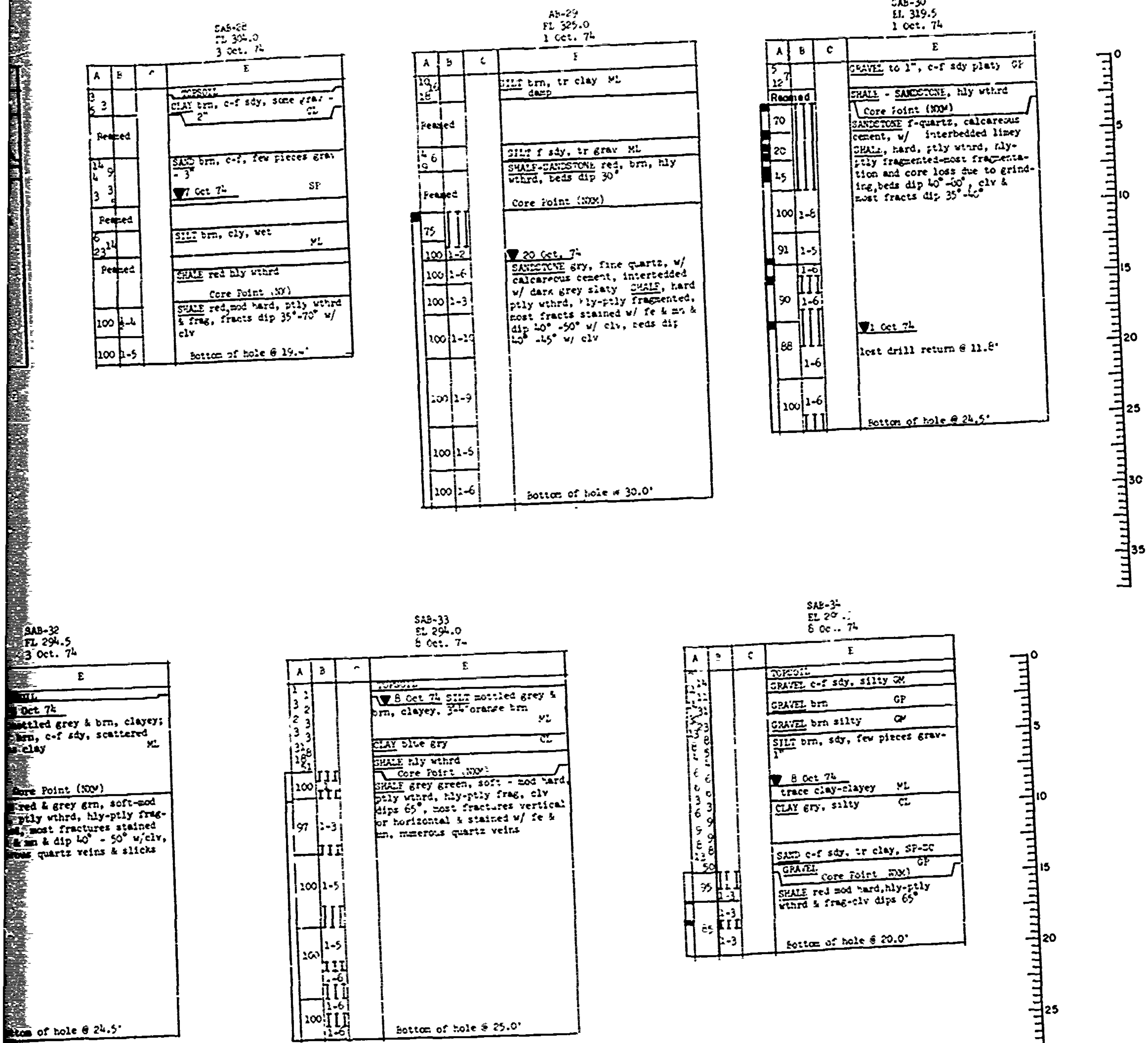
A	B	C	E
7 17			TOPSOIL
17 11 11			GRAVEL platy angular shale pieces -1½" GP-GM
6 6 5 6			SILT grey-brn, clayey 8 Oct 74 ML
12 22 27 22			GRAVEL platy angular shale pieces-2" GP-GM
25 9 19 54			SHALE red hly wthrd Core Point (NXM)
50			SHALE red, soft-mod hard, ptly wthrd, hly-ptly frag, most fracts stained w/ fe & mn & dip 75°-vertical w/ clv. few 15° opposite clv, few lenses sandstone
100			
100	1-3		
100	1-7		Bottom of hole @ 22.0'

SAB-32
EL 294.5
3 Oct. 74

A	B	C	E
1 5 2			TOPSOIL
Reamed			3 Oct 74 SILT mottled grey & brn, clayey; 5'-7' brn, c-f sdy, scattered lenses clay ML
26 16 20			Core Point (NXM)
100			SHALE red & grey grn, soft-mod hard, ptly wthrd, hly-ptly fragmented, most fractures stained w/fe & mn & dip 40° - 50° w/clv, numerous quartz veins & slicks
100			
100	1-3		
100	1-3		
100	1-8		
100	1-5		Bottom of hole @ 24.5'

A	B	C
1 2 3 2 3 3 3 31 36 51		
100		
	1-3	
100	1-5	
100	1-5	
	1-6	
	1-6	
100	1-6	

For abbreviations



SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

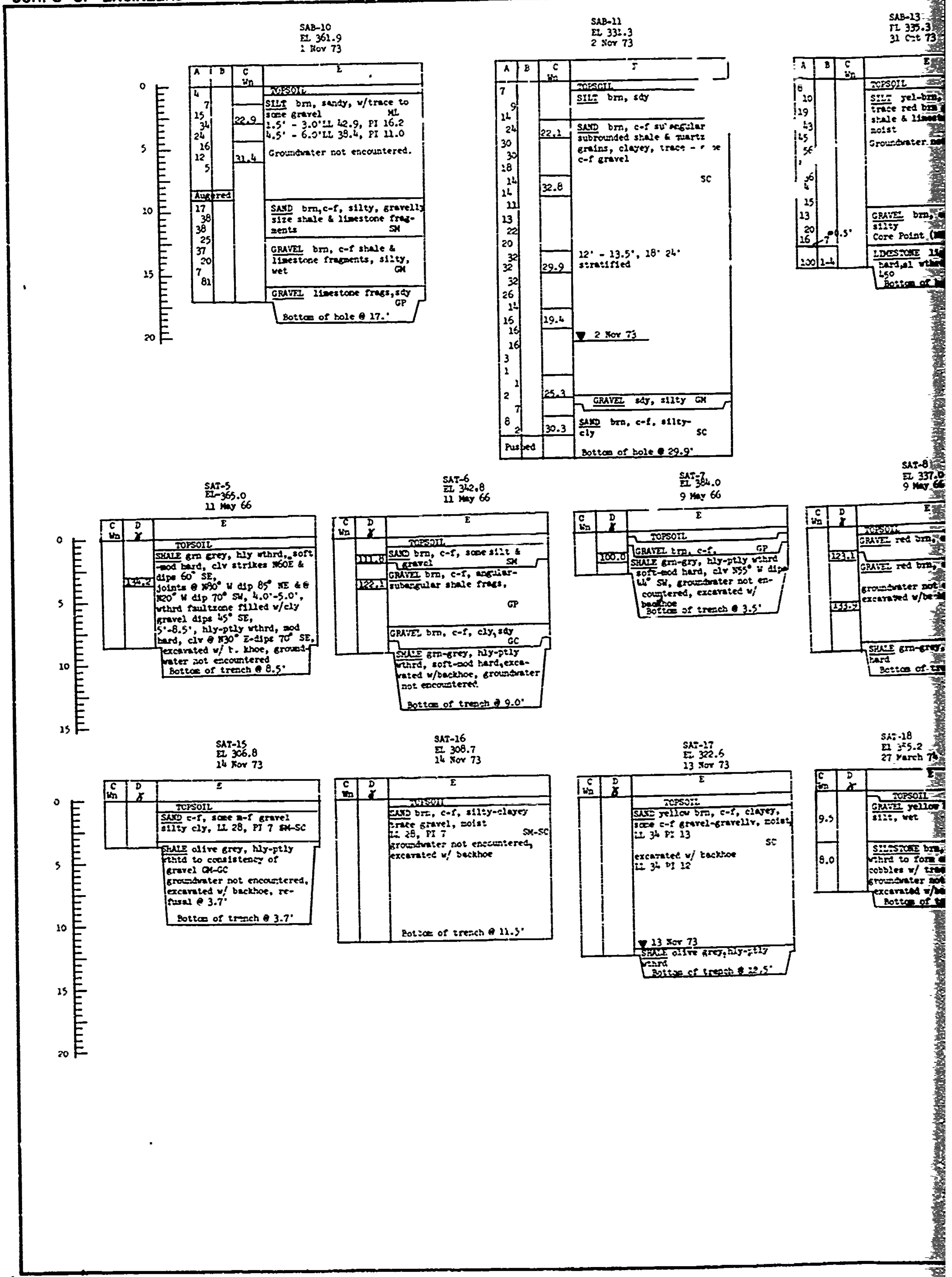
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

LOGS OF EXPLORATIONS
STRUCTURES

For abbreviations and symbols see plate A-1.

D.M. NO. 13 PLATE A-3

CORPS OF ENGINEERS



ML
some
SC
.0
66
GP
hly-ptly wthrd
lv N55° W dip
water not en-
untered
excavated w/
ench @ 3.5'
.6
73
-c-f, clayey,
gravelly, moist
SC
ackhoe
y, hly-ptly
ch @ 12.5'

SAB-13
EL 335.3
31 Oct 73

A	B	C Wn	E
			TOPSOIL
8, 10, 19, 43, 45, 56, 41, 36, 24, 15			SILT yel-brn, clayey, sandy, trace red brn gravel size shale & limestone fragments, moist. Groundwater not encountered. ML
13, 20, 16	@ 13.5'		GRAVEL brn, c-f, sandy silty. Core Point (100#)
100	1-4		LIMESTONE light - dk grey, hard, sl wthrd, beds dip 45°
			Bottom of hole @ 15.0'

SAB-14
EL 316.7
2 Nov 73

A	B Wn	C Wn	E
			TOPSOIL
7, 12		24	SAND brn, c-f, silty, some c-f gravel SM
23, 79			GRAVEL brn, c-f, sdy, some silty clay GC. Core Point (100#)
100	1-3		LIMESTONE dk gry, mod hard, ptly wthrd. groundwater not encountered
			Bottom of hole @ 6.0'

SAB-15
EL 320.0
31 Oct 73

A	B	C Wn	E
			TOPSOIL
10, 16, 39, 30, 66		14.9	SAND yel-brn, c-f, silty - clayey SC. Groundwater not encountered.
Augered 60		7.8	SHALE yel brn, hly wthrd to gravelly sand
Augered 76		7.1	Bottom of hole @ 8.0'

SAT-8
EL 337.0
9 May 66

C Wn	D γ	E
		TOPSOIL
	123.1	GRAVEL red brn, c-f, silty GM
		GRAVEL red brn, c-f, clayey, GC. groundwater not encountered, excavated w/backhoe
	135.7	
		SHALE grn-grey, ptly wthrd mod hard
		Bottom of trench @ 10.0'

SAT-12
EL 357.0
13 Nov 73

C Wn	D γ	E
		TOPSOIL
		GRAVEL yellow brn, c-f, some silty clay, GC
		SHALE olive grn, hly-wthrd to c-f gravel w/trace silty clay ground water not encountered, excavated w/ backhoe
		Bottom of trench @ 6.5'

SAT-13
EL 360.2
13 Nov 73

C Wn	D γ	E
		TOPSOIL
		GRAVEL brn, c-f, trace sand & clay GP-GC
		SHALE grn, hly-ptly wthrd, soft-mod hard most fa s ptly filled w/clay & dip 9°, groundwater not encountered, excavated w/ backhoe, has consistency of GP-GC
		Bottom of trench @ 12.5'

SAT-14
EL 343.6
13 Nov 73

C Wn	D γ	E
		TOPSOIL
		SHALE red, ptly wthrd mod hard, ground water not encountered, excavated w/ backhoe refusal @ 3.0'
		Bottom of trench @ 3.0'

SAT-18
EL 355.2
27 March 74

C Wn	D γ	E
		TOPSOIL
9.5		GRAVEL yellow brn, c-f trace silt, wet GP-GM
8.0		SILTSTONE brn, mod hard ptly wthrd to form of gravel & cobbles w/ trace of silt, groundwater not encountered excavated w/backhoe
		Bottom of trench @ 8.0'

SAT-19
EL 364.8
27 March 74

C Wn	D γ	E
		TOPSOIL
25	98.5	SILT yellow brn, clayey, some gravel size wthrd shale frags, ML
19.3		GRAVEL c-f, brn hly wthrd shale frags, sdy, some silt GM
14.5		SHALE brn, hly wthrd, soft. Cleavage S 70° 6'-10' pieces to 4" 10'-14' pieces to 8" 14'-20' pieces to 4" groundwater not encountered
13.2		
		Bottom of trench @ 20.0'

SAT-20
EL 358.7
28 March 74

C Wn	D γ	E
		TOPSOIL
24.5	102.7	SILT yellow brn, sandy, trace gravel to 2" ML
9.3		SHALE brn, hly wthrd, consists of soft to mod hard flat elongated shale fragments up to 12", 14.0'-17.0' slightly harder, groundwater not encountered. excavated w/backhoe
9.7		
		Bottom of trench @ 17.0'

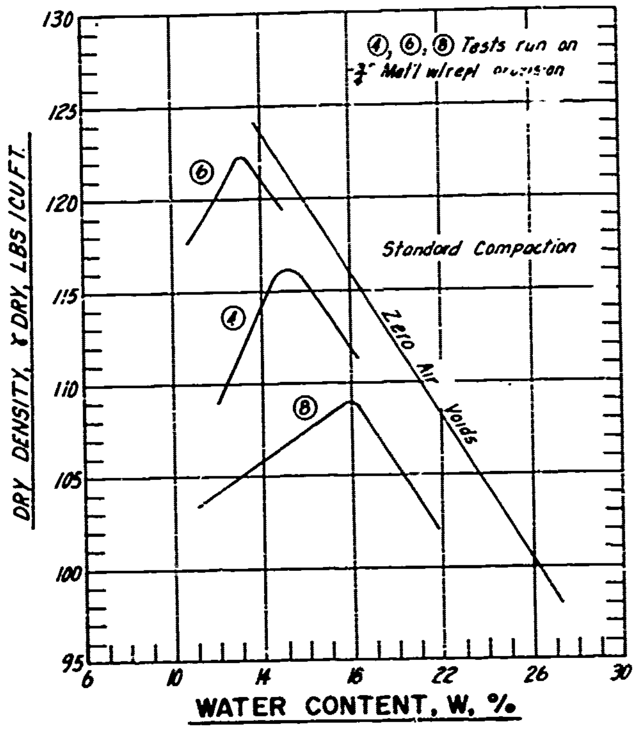
SAT-21
EL 355.1
26 March 74

C Wn	D γ	E
		TOPSOIL
23.5	105.4	SILT brn, some clay & gravel to 2" ML
		SHALE brn, soft, hly wthrd, in the form of silty gravel composed of flat elongated shale frags. 10.0'-14.0' pieces, to 3" X 4" X 6", groundwater not encountered excavated w/backhoe
		Bottom of trench @ 20.0'

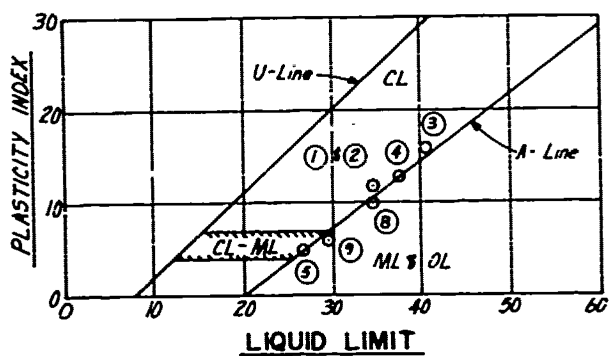
For abbreviations and symbols see plate A-1

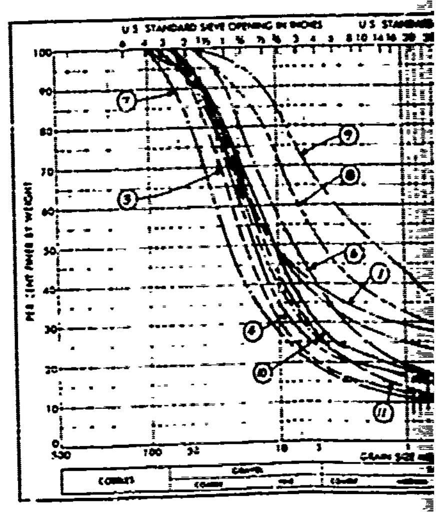
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
LOGS OF EXPLORATIONS
BORROW

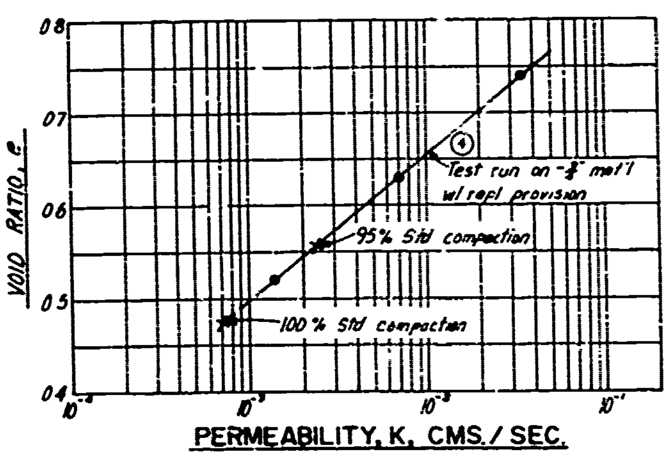


INDEX NUMBER	AREA & TRENCH NO	SAMPLE NUMBER	DEPTH IN FEET	SYMBOL
①	BRAVO SAT-12	S-1	0.5-1.4	GC
②	BRAVO SAT-12	S-2	1.4-5.5	GP-GC
③	BRAVO SAT-13	S-1	0.5-1.8	GP-GC
④	BRAVO SAT-13	S-2	1.8-11.5	GP-GC
⑤	SAT-14	S-1	0.5-3.0	GM-GC
⑥	* ALPHA SAT-18	S-1 thru S-4	0.5-4.0	GP-GM
⑦	ALPHA SAT-18	S-5	8.0	GP-GM
⑧	ALPHA SAT 19	S-6 thru S-10	5.0-10.0	GM
⑨	ALPHA SAT-19	S-11, S-12	18.0-19.0	SM
⑩	ALPHA SAT-20	S-5 thru S-9	3.0-5.5	GP-GM
⑪	ALPHA SAT-20	S-11, S-12	16.0-17.0	GP



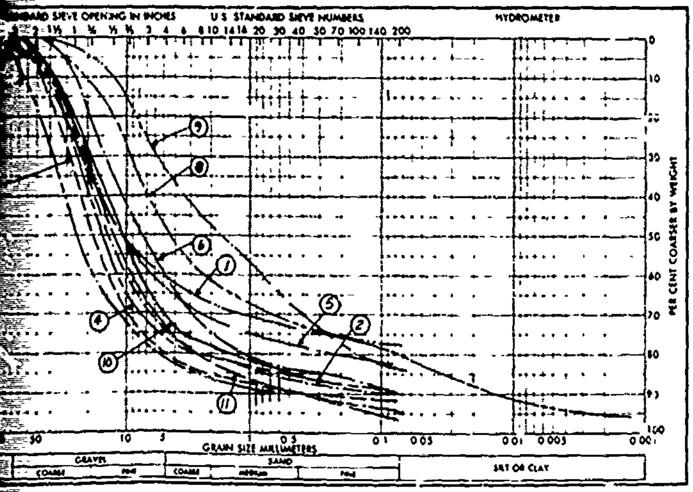


GRADATION



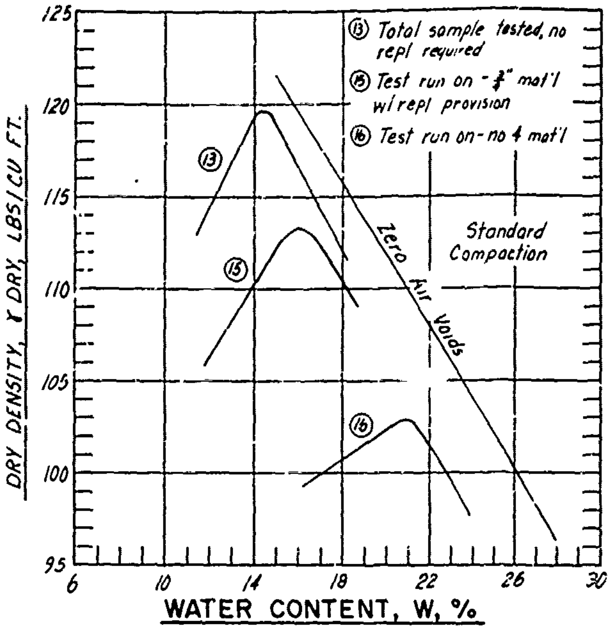
RANDOM FILL

SAMPLE NUMBER	DEPTH IN FEET	SYMBOL	LL	PL	PI	NAT W	OPT W	γ DRY MAX	e 95% γ MAX	e γ MAX
S-1	0 6 1 4	GC	35	23	12	-		-		-
S-2	1 4-6 5	GP-GC	35	23	12	-	-		-	-
S-1	0 6-1 8	GP-GC	41	25	16					
S-2	1 8-11 5	GP-GC	38	25	13	-	15 0	116 2	555	471
S-1	0 9-3 0	GM-GC	27	2	5	-	-		-	
S-1 thru S-4	0 5 4 0	GP-GM	NP		-	9 5	13 2	122 2	504	429
S-6	8 0	GP-GM	NP			8 0	-	-		-
S-6 thru S-10	5 0-10 0	GM	35	25	10	18 3	18 1	108 9	689	605
S-11, S-12	18 0-19 0	SM	30	24	6	13 2		-	-	
S-6 thru S-9	9 0-9 5	GP-GM	NP			9 3		-		-
S-11, S-12	16.0-17 0	GP	NP	-		9-7	-			-

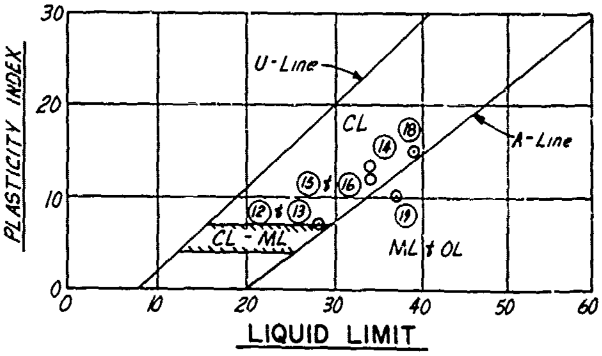


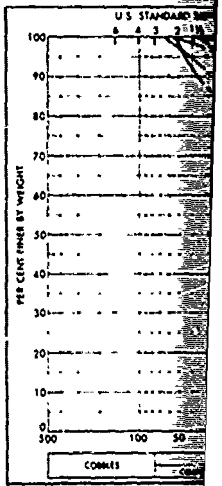
GRADATION CURVES

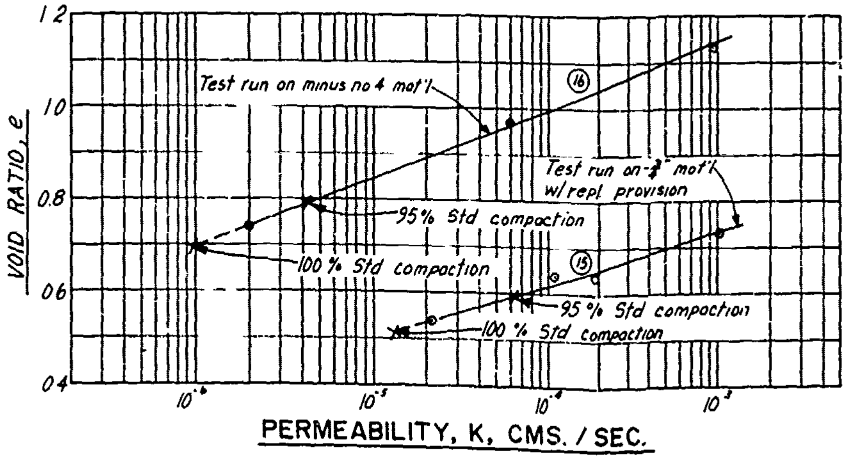
FILL



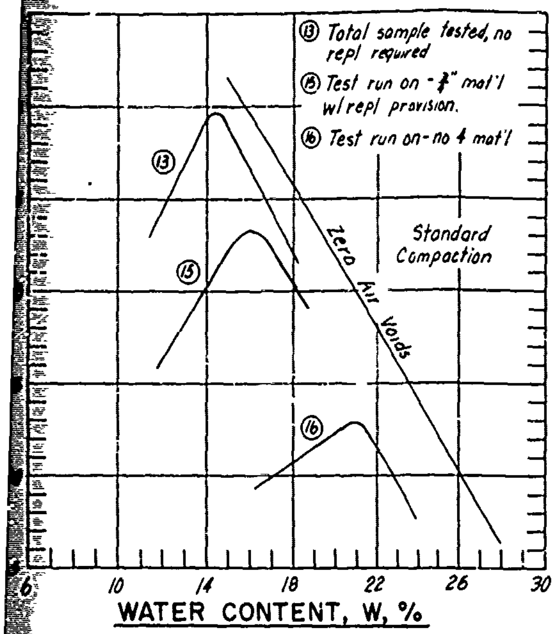
INDEX NUMBER	AREA & TRENCH NO
(12)	SAT-15
(13)	SAT 16
(14)	GRAVO SAT-17
(15)	BRAVO SAT 17
(16)	ALPHA SAT 19
(17)	ALPHA SAT-20
(18)	ALPHA SAT-21
(19)	ALPHA SAT 21



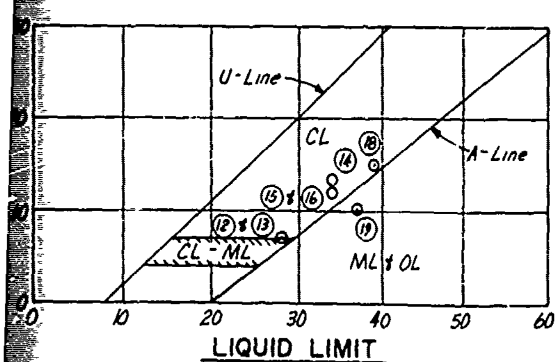


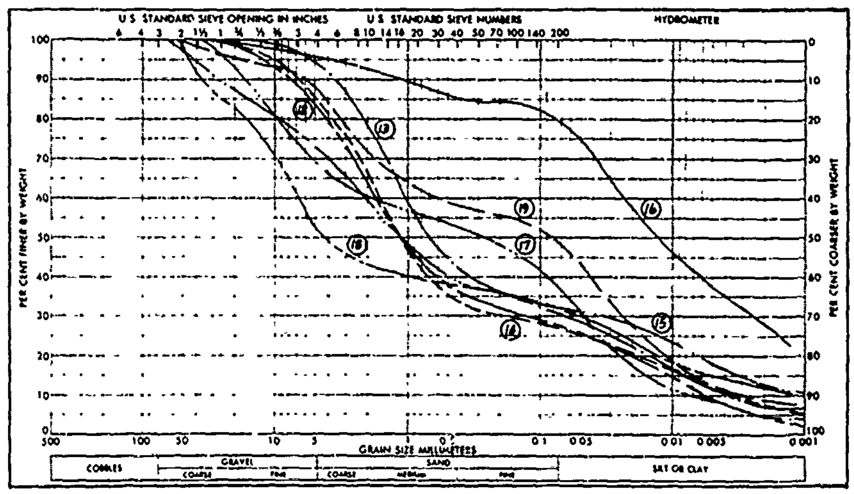


IMPERVIOUS FILL

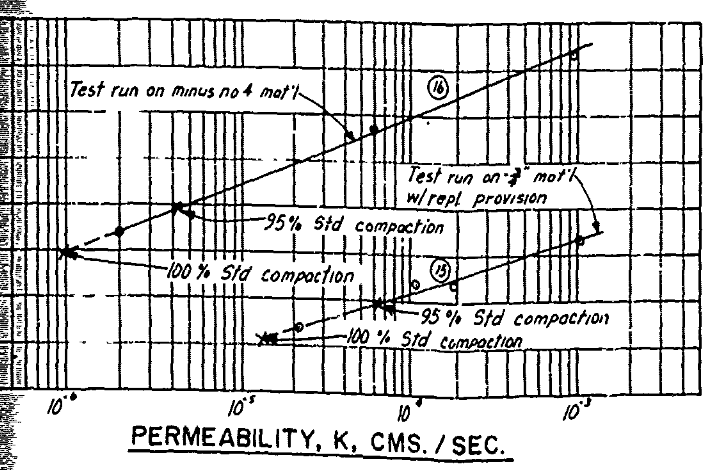


INDEX NUMBER	AREA & TRENCH NO	SAMPLE NUMBER	DEPTH IN FEET	SYMBOL	LL	PL	PI	NAT W	DRY INSITU	OPT W	γ DRY MAX	e 95%γMAX	e γ MAX
12	SAT 15	S 1	0 3-2 9	SM-SC	28	21	7		-			-	-
13	SAT-16	S-1	0 2 11 5	SM SC	28	21	7			14 4	119 7	541	464
14	BRAVO SAT-17	S-1	1 1-3 5	SC	34	21	13		-	-	-	-	-
15	BRAVO SAT 17	S 2	3 5 12 0	SC	34	22	12			16 0	113 4	592	513
16	ALPHA SAT 19	S 1 thru S-5	1 0 3 0	CL	34	22	12	25 0	98 5	21 1	103	786	695
17	ALPHA SAT-20	S-1 thru S 4	2 0-3 0	GM	NP	-	-	24 5	102 7		-		-
18	ALPHA SAT 21	S 1 thru S 4	1 0 3 5	GC	39	24	15	23 5	105 4	-	-		
19	ALPHA SAT 21	S 6 thru S-9	4 0 8 0	SM	37	27	10	20 3	-	-	-	-	-



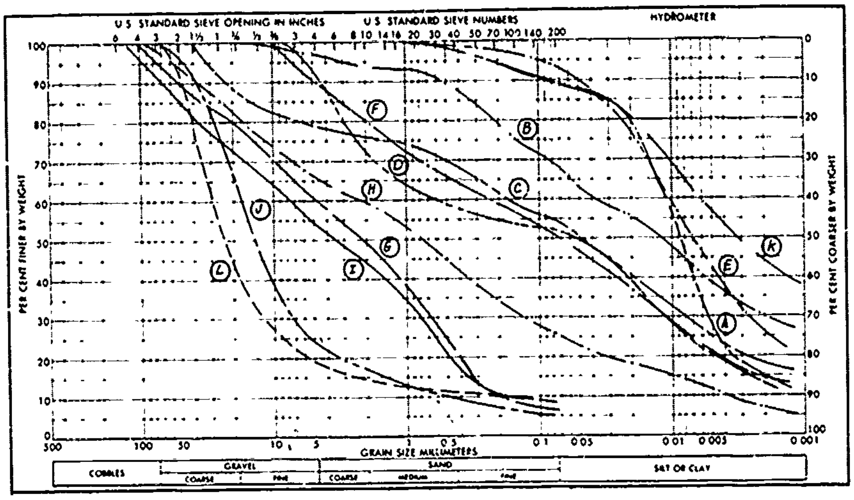


GRADATION CURVES

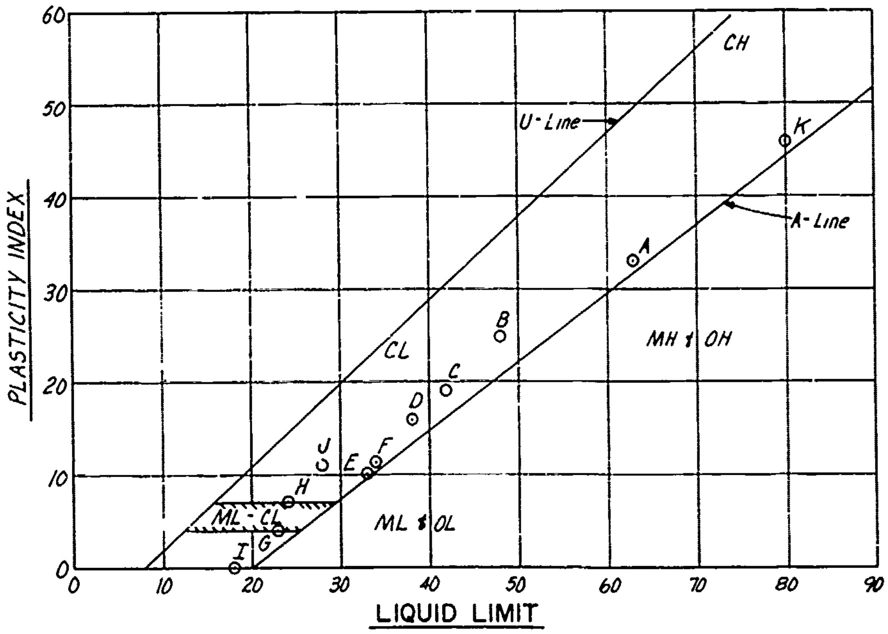


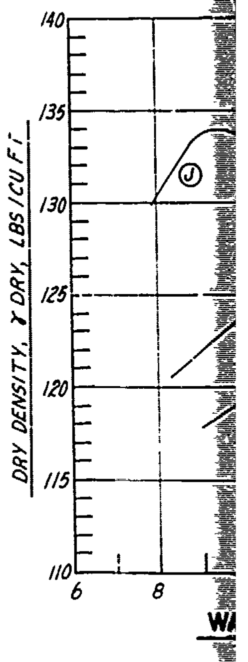
IMPERVIOUS FILL

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
RANDOM & IMPERVIOUS FILL SUMMARY
COMPACTION, ATTERBERG LIMITS, PERMEABILITY & GRAIN SIZE

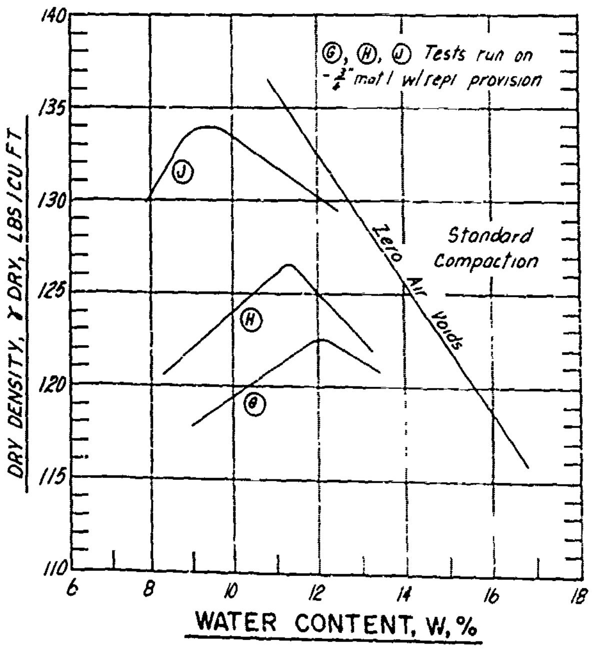


GRADATION CURVES





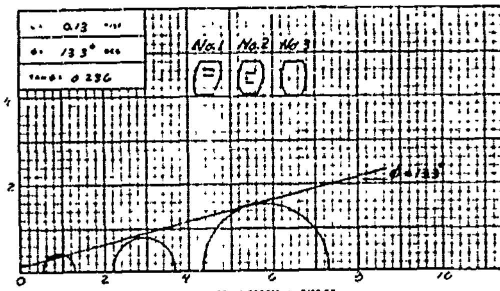
INDEX DESIGN	AREA AND HOLE OR TRENCH NO	SAMPLE NUMBER	DEPTH IN FEET	SYMBOL	LL	PL	PI	NAT W	γ DRY INSITU	OPT W	γ DRY MAX
A	LEVEE SAB 21U	U-1	2 0 4 0	OH	63	30	33	47 2	70 7	.	
B	LEVEE SAB 21U	U 2	4 0 6 0	CL	48	23	25	26 8	97 1	.	
C	LEVEE SAB 21U	U 2	4 0 6 0	CL	42	23	19	22 7		.	
D	FLANKING LEVEE SAB 23U	U 1	7 0-9 0	CL	38	22	16	20 4	104 2		
E	FLANKING LEVEE SAB 23U	U 2	9 0-11 0	CL	33	23	10	22 2	104 2		.
F	LEVEE SAB 25U	J 1	6 5-8 4	CL	34	23	11	19 2	102 4		.
G	RELOCATED CREEK SAT 10	S 1	1 1-2 0	SP SM	23	19	4			12	122 4
H	RELOCATED CREEK SAT 10	S 2	2 0-5 0	SM-SC	24	17	7	.	.	11 2	126 5
I	RELOCATED CREEK SAT 10	S 3	4 8-6 1	SP-SM	18	18	0		.	.	.
J	RELOCATED CREEK SAT 10	S 4	6 1-8 8	GP-GC	28	17	11		.	9 6	134 3
K	RELOCATED CREEK SAT 11	S 1	0 9-5 9	CH	80	34	46	.		.	.
L	RELOCATED CREEK SAT 11	S 2	5 9 8 7	GP-GM	.		.		.	.	

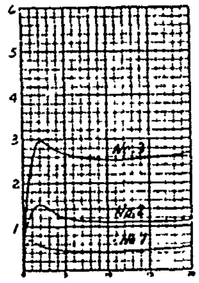


SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
FOUNDATION MATERIALS
SUMMARY
COMPACTION, ATTERBERG LIMITS, WATER CONTENT & GRAIN SIZE

D.M. NO. 13 PLATE A-6

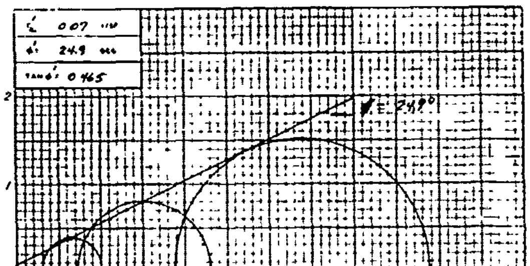
V

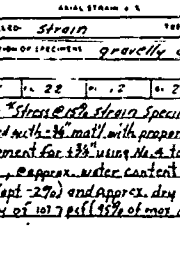




SPECIMEN NO		1	2	3	
INITIAL – WATER CONTENT %	w_o	13 1	13 7	13 4	
INITIAL – DRY DENSITY LB CU FT	γ_{d_o}	108 7	107 9	108 3	
INITIAL – SATURATION %	S_o	62 1	63 9	62 8	
INITIAL – VOID RATIO	e_o	579	591	586	
BEFORE SHEAR – WATER CONTENT %	w_c	20 8	19 2	16 9	
BEFORE SHEAR – DRY DENSITY LB CU FT	γ_{d_c}	109 3	112 3	108.3	
BEFORE SHEAR – SATURATION %	S_c	100	100	100	
BEFORE SHEAR – VOID RATIO	e_c	572	529	464	
BEFORE SHEAR – FINAL BACK PRESSURE T SQ FT	u_o	7 20	7 20	7 20	
MINOR PRINCIPAL STRESS T SQ FT	σ_3	0.54	2 16	4.32	
MAXIMUM DEVIATOR STRESS T SQ FT	$(\sigma_1-\sigma_3)_{max}$	0 71	1 53	2 98	
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN	t_1	90	90	90	
ULTIMATE DEVIATOR STRESS T SQ FT	$(\sigma_1-\sigma_3)_{ult}$	0 48*	1.11*	2 56*	
INITIAL DIAMETER IN	D_o	5 83	5 83	5 83	
INITIAL HEIGHT, IN	H_o	13 46	13 46	13 46	

CONTROLLED strain TEST





SPECIMEN NO		1	2	3	
INITIAL – WATER CONTENT %	w_o	13.1	13.7	13.4	
INITIAL – DRY DENSITY LB CU FT	γ_{d_o}	108.7	107.9	108 3	
INITIAL – SATURATION %	S_o				
INITIAL – VOID RATIO	e_o				
BEFORE SHEAR – WATER CONTENT %	w_c				
BEFORE SHEAR – DRY DENSITY LB CU FT	γ_{d_c}				
BEFORE SHEAR – SATURATION %	S_c				
BEFORE SHEAR – VOID RATIO	e_c				
BEFORE SHEAR – FINAL BACK PRESSURE T SQ FT	u_o				
MINOR PRINCIPAL STRESS T SQ FT	σ_3	0 28	0 73	1.87	
MAXIMUM DEVIATOR STRESS T SQ FT	$(\sigma_1-\sigma_3)_{max}$				
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN	t_1				
ULTIMATE DEVIATOR STRESS T SQ FT	$(\sigma_1-\sigma_3)_{ult}$				
Maj. Prin. Stress T/sf		0 99	2 26	4 85	
Pore Press. u_f T/sf		0 24*	1.43*	2 45*	

CONTROLLED Strain TEST

DESCRIPTION OF SPECIMENS gravelly clayey SAND(SC)

LL 34	PL 22	PI 12	Gs 2 75	TYPE OF SPECIMEN Remolded	TYPE OF TEST R

REMARKS *Stress @ 15% strain Specimens molded with -¾" mat'l with proportionate replacement for +¾" using No.4 to ¾" mat'l, @ approx. water content of 14% (opt -2%) and approx. dry density of 107 7 pcf (95% of max density)

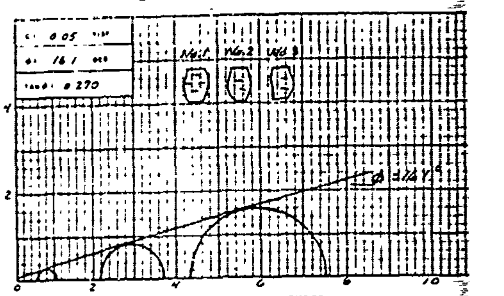
PROJECT Bernville Protective Works

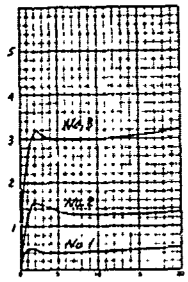
BORING NO SAT-17 SAMPLE NO S-2

DEPTH/ELEV 3 5'-12 0'

LABORATORY NED DATE April 1974

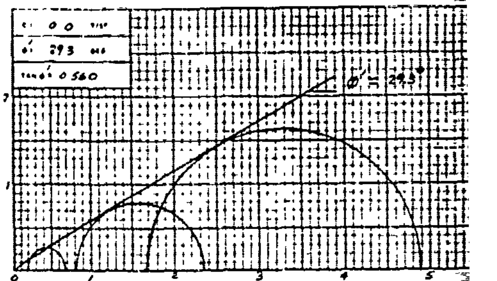
TRIAXIAL COMPRESSION TEST REPORT

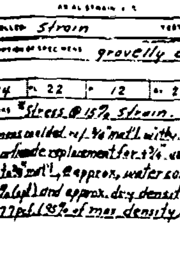




SPECIMEN NO		1	2	3
INITIAL – WATER CONTENT %	w_o	15.7	16.1	16.[illegible]
INITIAL – DRY DENSITY LB CU FT	γ_{d_o}	108 0	107 7	10[illegible]
INITIAL – SATURATION %	S_o	73 4	74.3	7[illegible]
INITIAL – VOID RATIO	e_o	590	594	.5[illegible]
BEFORE SHEAR – WATER CONTENT %	w_c	20 4	18 6	17.[illegible]
BEFORE SHEAR – DRY DENSITY LB CU FT	γ_{d_c}	110 0	113.7	11[illegible]
BEFORE SHEAR – SATURATION %	S_c	100	100	10[illegible]
BEFORE SHEAR – VOID RATIO	e_c	560	.510	.4[illegible]
BEFORE SHEAR – FINAL BACK PRESSURE T/SQ FT	u_o	7 20	7 20	7.2[illegible]
MINOR PRINCIPAL STRESS T SQ FT	σ_3	0 54	2 16	4.3[illegible]
MAXIMUM DEVIATOR STRESS T SQ FT	$(\sigma_1-\sigma_3)_{max}$	0 49	1 52	3 2[illegible]
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN	t_1	6 9	10 3	12[illegible]
ULTIMATE DEVIATOR STRESS T SQ FT	$(\sigma_1-\sigma_3)_{ult}$	0 47*	1 29*	3.[illegible]
INITIAL DIAMETER IN	D_o	5.83	5 83	5.[illegible]
INITIAL HEIGHT IN	H_o	13.46	13 46	13.[illegible]

CONTROLLED strain TEST





SPECIMEN NO		1	2	3
INITIAL – WATER CONTENT %	w_o	15 7	16.1	16.[illegible]
INITIAL – DRY DENSITY LB CU FT	γ_{d_o}	108 0	107.7	107[illegible]
INITIAL – SATURATION %	S_o			
INITIAL – VOID RATIO	e_o			
BEFORE SHEAR – WATER CONTENT %	w_c			
BEFORE SHEAR – DRY DENSITY LB CU FT	γ_{d_c}			
BEFORE SHEAR – SATURATION %	S_c			
BEFORE SHEAR – VOID RATIO	e_c			
BEFORE SHEAR – FINAL BACK PRESSURE T SQ FT	u_o			
MINOR PRINCIPAL STRESS T SQ FT	σ_3	0 19	0.81	1.6[illegible]
MAXIMUM DEVIATOR STRESS T SQ FT	$(\sigma_1-\sigma_3)_{max}$			
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN	t_1			
ULTIMATE DEVIATOR STRESS T SQ FT	$(\sigma_1-\sigma_3)_{ult}$			
Maj. Prin. Stress T/sf		0 68	2 33	4.8[illegible]
Pore Press. u_f T/sf		0 35*	[illegible]5*	2.[illegible]

CONTROLLED Strain TEST

DESCRIPTION OF SPECIMENS gravelly clayey SAND (SC)

LL 34	PL 22	PI 12	Gs 2 75	TYPE OF SPECIMEN Remolded	TYPE OF TEST

REMARKS *Stress @ 15% Strain. Specimens molded w/ -¾" mat'l with proportionate replacement for +¾" using No.4 to ¾" mat'l, @ approx. water content of 14% (opt) and approx. dry density of 107.7 pcf (95% of max density).

PROJECT Bernville Protective Work[illegible]

BORING NO SAT-17 SAMPLE NO S-2[illegible]

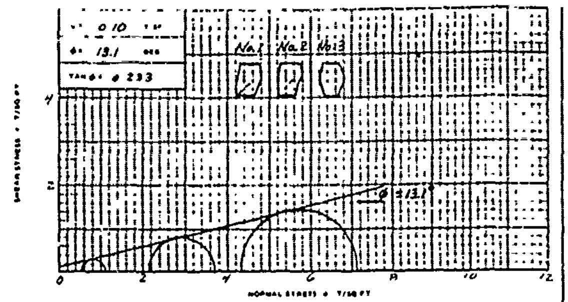
DEPTH/ELEV 3.5'-12 0'

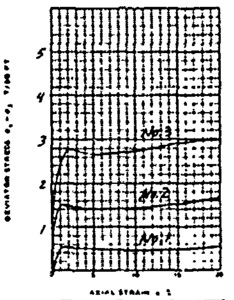
LABORATORY NED DATE April 1[illegible]

TRIAXIAL COMPRESSION TEST REPORT

R & R̄ TESTS

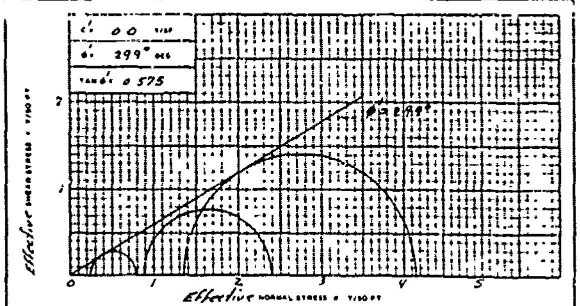
INDEX NO. 15

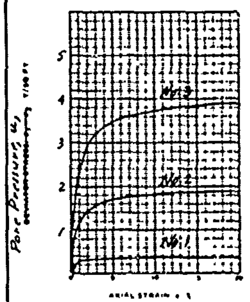




SPECIMEN NO			1	2	3	
INITIAL	WATER CONTENT %	w_0	17.3	17.6	18.1	
	DRY DENSITY LB CU FT	γ_{d_0}	108.5	108.0	102.7	
	SATURATION %	S_0	81.7	83.3	84.1	
	VOID RATIO	e_0	.501	.509	.573	
BEFORE SHEAR	WATER CONTENT %	w_c	20.1	18.0	17.0	
	DRY DENSITY LB CU FT	γ_{d_c}	110.5	114.9	117.0	
	SATURATION %	S_c	100	100	100	
	VOID RATIO	e_c	.553	494	465	
	FINAL BACK PRESSURE T/SQ FT	u_0	7.20	7.20	7.20	
MINOR PRINCIPAL STRESS T SQ FT		σ_3	0.54	2.16	4.32	
MAXIMUM DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{max}$	0.54	1.51	2.19	
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN		t_1	6.9	6.0	12.0	
ULTIMATE DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{ult}$	0.55*	1.51*	2.02*	
INITIAL DIAMETER IN		D_0	5.83	5.83	5.83	
INITIAL HEIGHT IN		H_0	13.46	13.46	13.46	

CONTROLLED- Strain TEST





SPECIMEN NO			1	2	3	
INITIAL	WATER CONTENT %	w_0	17.3	17.8	18.1	
	DRY DENSITY LB CU FT	γ_{d_0}	108.6	108.0	107.7	
	SATURATION %	S_0				
	VOID RATIO	e_0				
BEFORE SHEAR	WATER CONTENT %	w_c				
	DRY DENSITY LB CU FT	γ_{d_c}				
	SATURATION %	S_c				
	VOID RATIO	e_c				
	FINAL BACK PRESSURE T/SQ FT	u_0				
MINOR PRINCIPAL STRESS T/SQ FT		σ_3	0.23	0.87	1.35	
MAXIMUM DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{max}$				
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN		t_1				
ULTIMATE DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{ult}$				
Max Pore Press., T/F		u_f	0.77	2.38	4.14	
Pore Press., T/F			0.31*	1.27*	1.97*	

CONTROLLED- Strain TEST

DESCRIPTION OF SPECIMENS gravelly clayey SAND (SC)

LL 34	PL 22	PI 12	G 2.75	TYPE OF SPECIMEN Remolded	TYPE OF TEST R

REMARKS *Stress @ 15% Strain. Specimens molded with -3/4" mat'l. with proportionate replacement for +3/4" using No.4 to 3/4" mat'l, @ approx. water content of 18% (opt. 12%) and approx. dry density of 102.2 pcf (95% of max.)

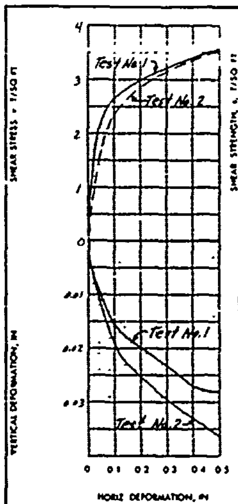
PROJECT Bernville Protective Works

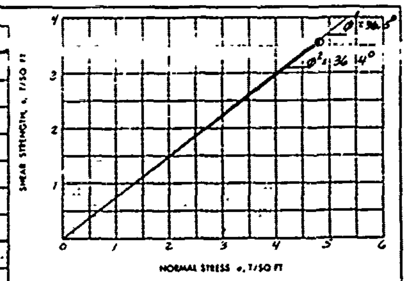
BORING NO SAT-17 SAMPLE NO S-2

DEPTH ELEV 3.5'-12.0'

LABORATORY NED DATE April 1974

TRIAXIAL COMPRESSION TEST REPORT





SHEAR STRENGTH PARAMETERS

φ = 36.4°

TAN φ = 0.737

c = 0.0 T/SQ FT

☐ CONTROLLED STRESS
☒ CONTROLLED STRAIN

TEST NO			1	2		
INITIAL	WATER CONTENT	w_0	19.3%	19.3%	%	%
	VOID RATIO	e_0	.631	638		
	SATURATION	S_0	85.3%	84.4%	%	%
	DRY DENSITY LB/CU FT	γ_d	106.0	106.3		
VOID RATIO AFTER CONSOLIDATION		e_c	0.513	489		
TIME FOR 50 PERCENT CONSOLIDATION MIN		t_{50}	0.70	0.40		
FINAL	WATER CONTENT	w_f	18.2%	17.9%	%	%
	VOID RATIO	e_f	.474	.374		
	SATURATION	S_f	100%	100%	%	%
NORMAL STRESS T/SQ FT		σ	4.60	4.60		
MAXIMUM SHEAR STRESS T/SQ FT		τ_{max}	3.56*	3.54*		
ACTUAL TIME TO FAILURE MIN		t_f	61.4	60.5		
RATE OF STRAIN, IN/MIN			0.0081	0.0083		
ULTIMATE SHEAR STRESS T/SQ FT		τ_{ult}	—	—		

TYPE OF SPECIMEN - Remolded			3.0 IN SQUARE	0.50 IN THICK
CLASSIFICATION gravelly clayey SAND (SC)				
LL 34	PL 22	PI 12		G 2.79

REMARKS *Stresses @ 5" Deformation; Specimens molded with -No.4 mat'l. @ approx. water content of 19.3% (opt 12%) and approx. dry density of 106.5 pcf (95% of max. density);

PROJECT Bernville Protective Works

AREA Borrow Area Bravo

BORING NO SAT-17 SAMPLE NO S-2

DEPTH FT 3.5'-12.0' DATE April 1974

DIRECT SHEAR TEST REPORT

ENG FORM PLATE III-3

S TEST

INDEX NO. 15

Note

1. Refer to plate A-5 for lab test summar

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

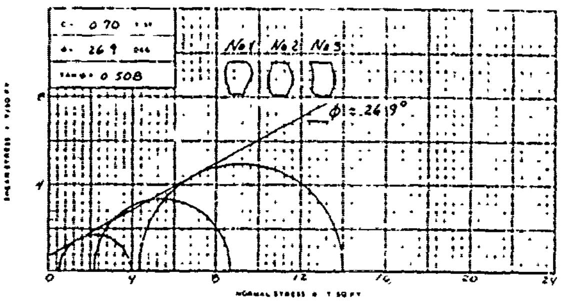
BLUE MARSH LAKE

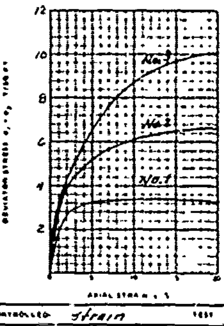
BERNVILLE PROTECTIVE WORKS

IMPERVIOUS FILL
SAT-17

SHEAR TEST REPORTS

D.M. NO. 13 PLATE





SPECIMEN NO		1	2	3
INITIAL	WATER CONTENT %	13.6	13.6	13.6
	DRY DENSITY LB CU FT	107.9	107.9	107.9
	SATURATION %	63.1	63.1	63.1
	VOID RATIO	.591	.591	.591
BEFORE SHEAR	WATER CONTENT %			
	DRY DENSITY LB CU FT			
	SATURATION %			
	VOID RATIO			
	FINAL BACK PRESSURE T SQ FT			
MINOR PRINCIPAL STRESS T SQ FT		0.54	2.16	4.32
MAXIMUM DEVIATOR STRESS T SQ FT		3.37	6.50*	9.68*
TIME TO FAILURE MIN		7.3	15	15
ULTIMATE DEVIATOR STRESS T SQ FT		3.39*	—	—
INITIAL DIAMETER IN		5.83	5.83	5.83
INITIAL HEIGHT IN		13.46	13.46	13.46

CONTROLLED strain TEST

DESCRIPTION OF SPECIMENS gravelly clayey SAND (SC)

LL 34 PL 22 PI 12 Gs 2.75 | TYPE OF SPECIMEN Remolded | TYPE OF TEST Q

REMARKS *Stress@15% Strain. Specimens molded with -¾" mat'l with proportionate replacement for +¾" using No.4 to ¾" mat'l, @approx. water content of 14% (opt. -2%) and approx. dry density of 107.7 pcf (95% of max den.)

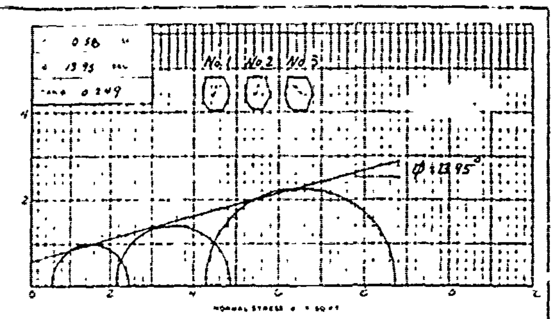
PROJECT Bernville Protective Works

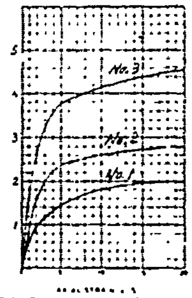
BORING NO SAT-17 SAMPLE NO S-2

DEPTH/ELEV 3.5'-12.0'

LABORATORY NED DATE April 1974

TRIAXIAL COMPRESSION TEST REPORT





SPECIMEN NO		1	2	3
INITIAL	WATER CONTENT %	15.7	15.7	15.7
	DRY DENSITY LB CU FT	108.0	108.0	108.0
	SATURATION %	73.4	73.4	73.4
	VOID RATIO	.590	.590	.590
BEFORE SHEAR	WATER CONTENT %			
	DRY DENSITY LB CU FT			
	SATURATION %			
	VOID RATIO			
	FINAL BACK PRESSURE T SQ FT			
MINOR PRINCIPAL STRESS T SQ FT		0.54	2.16	4.32
MAXIMUM DEVIATOR STRESS T SQ FT		1.94*	2.72*	4.40*
TIME TO FAILURE MIN		15	15	15
ULTIMATE DEVIATOR STRESS T SQ FT		—	—	—
INITIAL DIAMETER IN		5.83	5.83	5.83
INITIAL HEIGHT IN		13.46	13.46	13.46

CONTROLLED strain TEST

DESCRIPTION OF SPECIMENS gravelly clayey SAND (SC)

LL 34 PL 22 PI 12 Gs 2.75 | TYPE OF SPECIMEN Remolded | TYPE OF TEST Q

REMARKS *Stress@15% Strain. Specimens molded with -¾" mat'l with proportionate replacement for +¾" using No.4 to ¾" mat'l, @approx. water content of 16% (opt) and approx dry den. of 107.7 pcf (95% of max. den.)

PROJECT Bernville Protective Works

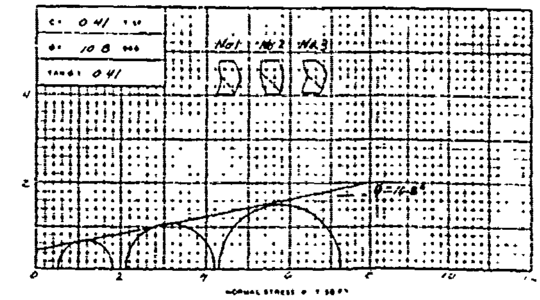
BORING NO SAT-17 SAMPLE NO S-2

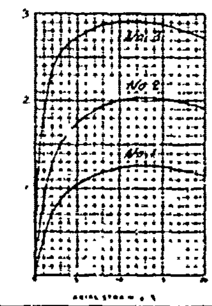
DEPTH/ELEV 3.5'-12.0'

LABORATORY NED DATE April 1974

TRIAXIAL COMPRESSION TEST REPORT

Q TESTS
INDEX NO. 15





SPECIMEN NO		1	2	3
INITIAL	WATER CONTENT %	23.1	23.1	23.1
	DRY DENSITY LB CU FT	97.7	97.7	97.7
	SATURATION %	82	82	82
	VOID RATIO	.788	.788	.788
BEFORE SHEAR	WATER CONTENT %			
	DRY DENSITY LB CU FT			
	SATURATION %			
	VOID RATIO			
	FINAL BACK PRESSURE T SQ FT			
MINOR PRINCIPAL STRESS T SQ FT		0.54	2.16	4.32
MAXIMUM DEVIATOR STRESS T SQ FT		1.23	2.02	2.91
TIME TO FAILURE MIN		13	12	10
ULTIMATE DEVIATOR STRESS T SQ FT		1.22*	2.01*	2.86*
INITIAL DIAMETER IN		2.80	2.80	2.80
INITIAL HEIGHT IN		6.35	6.35	6.35

CONTROLLED strain TEST

DESCRIPTION OF SPECIMENS sandy CLAY (CL)

LL 34 PL 22 PI 12 Gs 2.80 | TYPE OF SPECIMEN Remolded | TYPE OF TEST Q

REMARKS *Stress@15% strain. Specimens molded with -No.4 mat'l @approx. water content of 23.1% (opt +2%) and dry density of 97.9 pcf (95% of maximum density)

PROJECT Bernville Protective Works

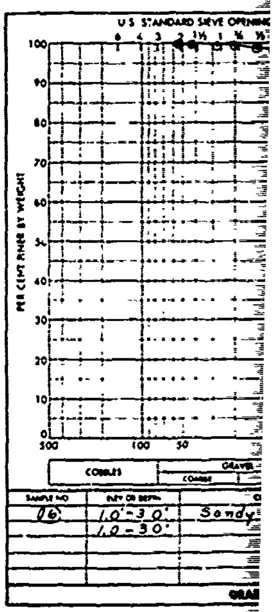
BORING NO SAT-19 SAMPLE NO S-53, 53, 54, 55

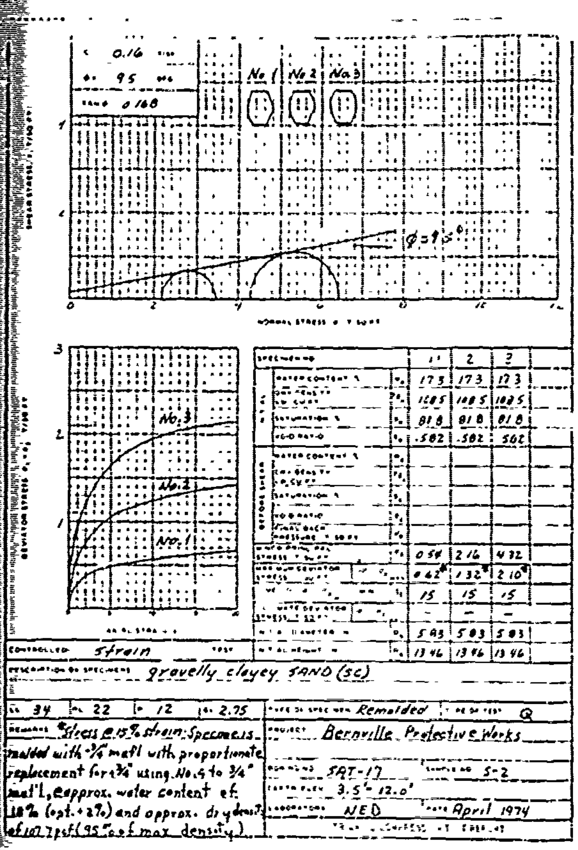
DEPTH/ELEV 1.0'-3.0'

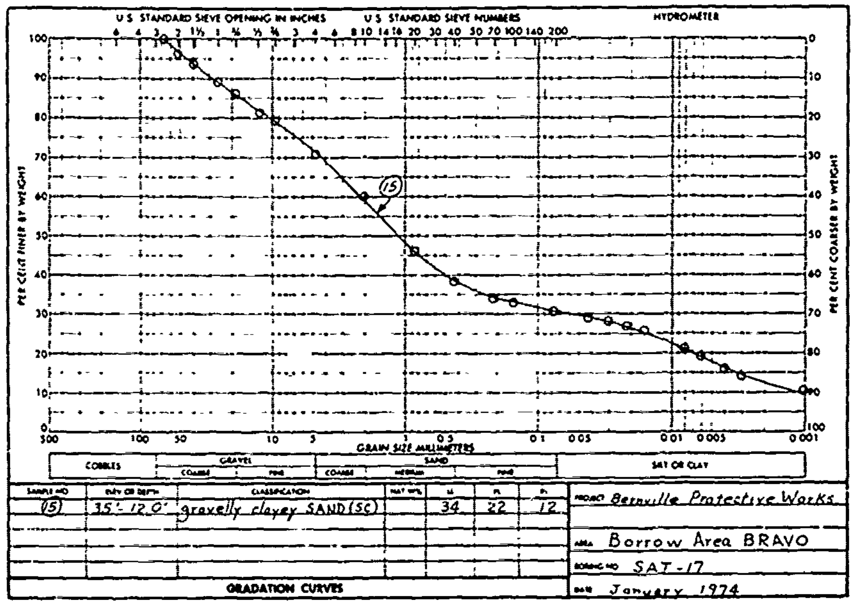
LABORATORY NED DATE May 1974

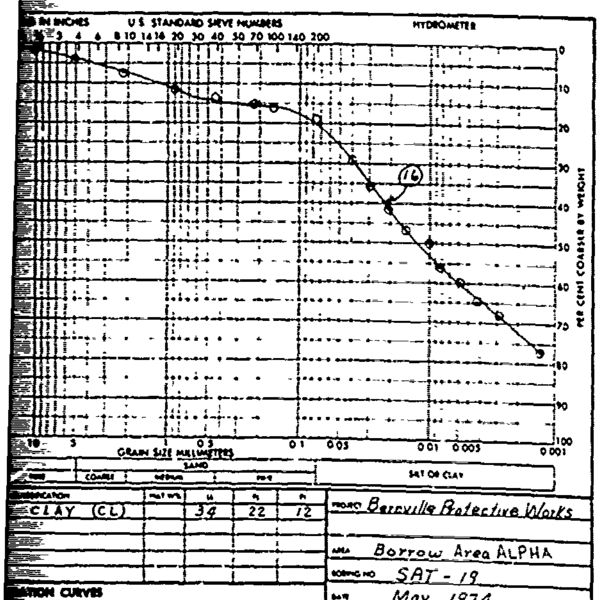
TRIAXIAL COMPRESSION TEST REPORT

Q TEST
INDEX NO. 16









Note
1 Refer to plate A-5 for lab test summary

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

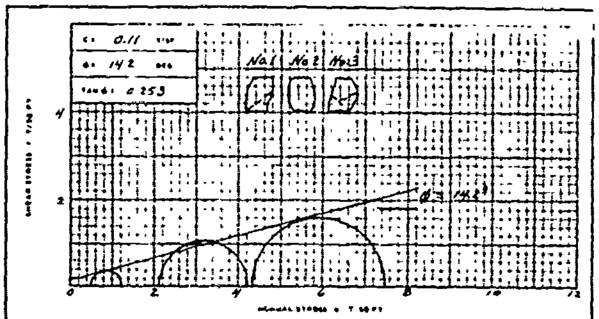
BLUE MARSH LAKE

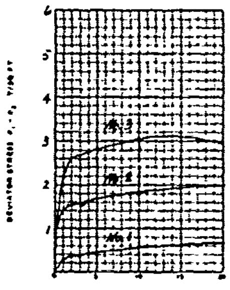
BERNVILLE PROTECTIVE WORKS

IMPERVIOUS FILL
SAT 17 & 19

SHEAR TEST REPORTS

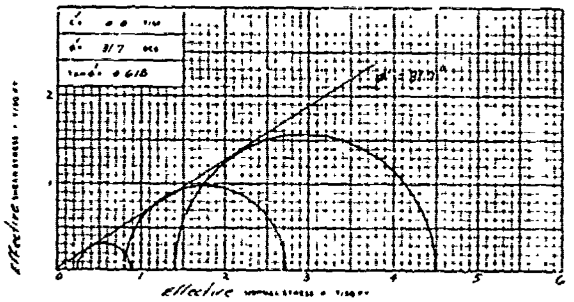
D.M. NO. 13 PLATE

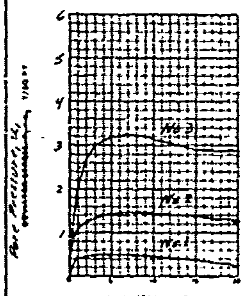




Specimen no.			1	2	3	
Initial	Water content %	w_0	18 9	18 9	18 8	
	Dry density lb/cu ft	γ_{d0}	98 5	98 6	98 0	
	Saturation %	S_0	69	69	67	
	Void ratio	e_0	774	771	783	
Before shear	Water content %	w_c	26 4	25 3	24 9	
	Dry density lb/cu ft	γ_{dc}	99 8	102 2	102.9	
	Saturation %	S_c	100	100	100	
	Void ratio	e_c	750	709	698	
	Final back pressure T/sq ft	u_0	7 20	7 20	7 20	
Minor principal stress T/sq ft		σ_3	0 54	2 16	4 32	
Maximum deviator stress T/sq ft	$(\sigma_1-\sigma_3)_{max}$		0 62*	1 97*	3 14*	
Time to $(\sigma_1-\sigma_3)_{max}$ min		t_1	105	105	105	
Ultimate deviator stress T/sq ft	$(\sigma_1-\sigma_3)_{ult}$		—	—	—	
Initial diameter in		D_0	2 80	2 80	2 80	
Initial height in		H_0	6 31	6 30	6 35	

Controlled strain test





Specimen no.			1	2	3	
Initial	Water content %	w_0	18 9	18 9	18 8	
	Dry density lb/cu ft	γ_{d0}	98 5	98 6	98 0	
	Saturation %	S_0	69	69	67	
	Void ratio	e_0	774	771	783	
Before shear	Water content %	w_c				
	Dry density lb/cu ft	γ_{dc}				
	Saturation %	S_c				
	Void ratio	e_c				
	Final back pressure T/sq ft	u_0				
Minor principal stress T/sq ft		σ_3	0 25	0 79	1 40	
Maximum deviator stress T/sq ft	$(\sigma_1-\sigma_3)_{max}$					
Time to $(\sigma_1-\sigma_3)_{max}$ min		t_1				
Ultimate deviator stress T/sq ft	$(\sigma_1-\sigma_3)_{ult}$					
Max. Prin. Stress, TSF		$\bar{\sigma}_1$	0 96	2 76	4 48	
Pore Press. TSF		Δu	0 39	1 37	2 92	

Controlled strain test

Description of specimens: sandy CLAY (CL)

LL 34 PL 22 PI 12 Gs 2 80

Remarks: *Stress @ 15% strain. Specimens molded with -No 4 mat'l. @ approximate water content of 19.1% (opt -2) and dry density of 97.9 pcf (95% of maximum density)

Type of specimen: Remolded Type of test: R

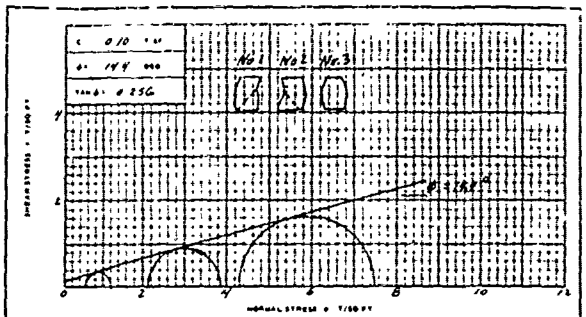
Project: Bernville Protective Works

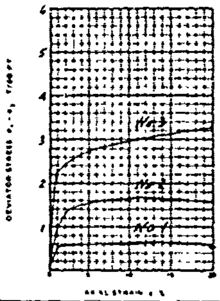
Boring no. SAT-19 Sample no. S1, S2, S3, S4, S5

Depth: 1.0'-3.0'

Laboratory: NED Date: May 1974

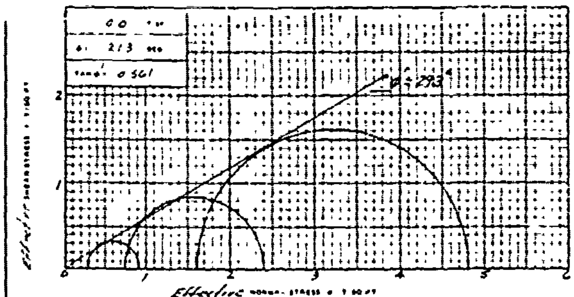
TRIAXIAL COMPRESSION TEST REPORT

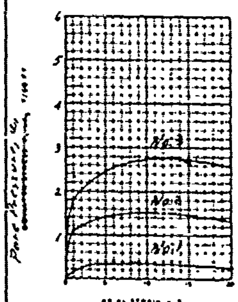




Specimen no.			1	2	3	
Initial	Water content %	w_0	20 8	20 5	20 6	
	Dry density lb/cu ft	γ_{d0}	98 8	97 9	97 6	
	Saturation %	S_0	76	73	73	
	Void ratio	e_0	768	785	791	
Before shear	Water content %	w_c	27 7	26 6	24 7	
	Dry density lb/cu ft	γ_{dc}	99 3	100 2	103 3	
	Saturation %	S_c	100	100	100	
	Void ratio	e_c	760	743	691	
	Final back pressure T/sq ft	u_0	7 20	7 20	7 20	
Minor principal stress T/sq ft		σ_3	0 54	2 16	4 32	
Maximum deviator stress T/sq ft	$(\sigma_1-\sigma_3)_{max}$		0 61	1 65	3 16*	
Time to $(\sigma_1-\sigma_3)_{max}$ min		t_1	43	92	105	
Ultimate deviator stress T/sq ft	$(\sigma_1-\sigma_3)_{ult}$		0 60*	1 63*	—	
Initial diameter in		D_0	2 80	2 80	2 80	
Initial height in		H_0	6 30	6 30	6 30	

Controlled strain test





Specimen no.			1	2	3	
Initial	Water content %	w_0	20 8	20 5	20 6	
	Dry density lb/cu ft	γ_{d0}	98 8	97.9	97.6	
	Saturation %	S_0	76	73	73	
	Void ratio	e_0	768	785	.791	
Before shear	Water content %	w_c				
	Dry density lb/cu ft	γ_{dc}				
	Saturation %	S_c				
	Void ratio	e_c				
	Final back pressure T/sq ft	u_0				
Minor principal stress T/sq ft		σ_3	0 28	0.74	1 62*	
Maximum deviator stress T/sq ft	$(\sigma_1-\sigma_3)_{max}$					
Time to $(\sigma_1-\sigma_3)_{max}$ min		t_1				
Ultimate deviator stress T/sq ft	$(\sigma_1-\sigma_3)_{ult}$					
Max. Prin. Stress, TSF		$\bar{\sigma}_1$	0 89	2 39	4.78*	
Pore Press. TSF		Δu	0 26	1 42	2 70	

Controlled strain test

Description of specimens: sandy CLAY (CL)

LL 34 PL 22 PI 12 Gs 2 80

Remarks: *Stress @ 15% strain. Specimens molded with -No 4 mat'l. @ approx. water content of 21.1% (opt.) and dry density of 97.9 pcf. (95% of maximum density)

Type of specimen: Remolded Type of test: R

Project: Bernville Protective Works

Boring no. SAT-19 Sample no. S1, S2, S3, S4, S5

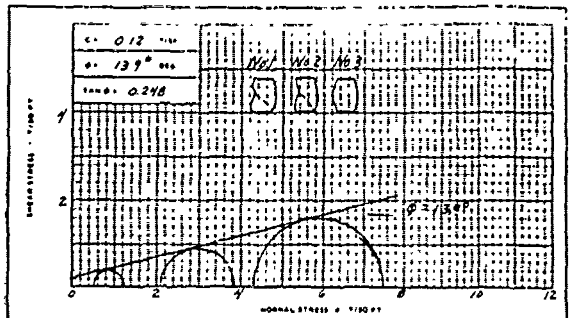
Depth/Elev: 1.0'-3.0'

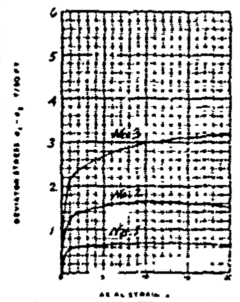
Laboratory: NED Date: May 1974

TRIAXIAL COMPRESSION TEST REPORT

R & $\bar{R}$ TESTS

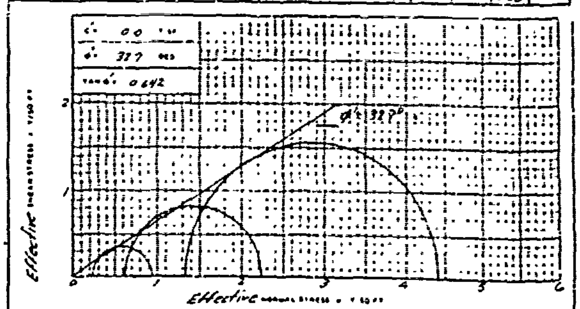
INDEX NO. 16

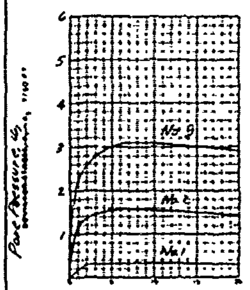




SPECIMEN NO		1	2	3
INITIAL: WATER CONTENT %	w_o	23 5	23 5	23.5
INITIAL: DRY DENSITY LB/CU FT	γ_o	98 1	98 2	97.4
INITIAL: SATURATION %	S_o	84 2	84 4	83 1
INITIAL: VOID RATIO	e_o	.781	780	794
BEFORE SHEAR: WATER CONTENT %	w_c	27 2	25 0	23 8
BEFORE SHEAR: DRY DENSITY LB/CU FT	γ_c	99 2	102 8	104 9
BEFORE SHEAR: SATURATION %	S	100	100	100
BEFORE SHEAR: VOID RATIO	e_c	762	699	666
BEFORE SHEAR: FINAL BACK PRESSURE T/SQ FT	u_o	7 20	7 20	7 20
MINOR PRINCIPAL STRESS T/SQ FT	σ_3	0 54	2 16	4 32
MAXIMUM DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{max}$	0 67	1 62	3 10*
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN	t_f	82	67	90
ULTIMATE DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{ult}$	0 66*	1 58*	—
INITIAL DIAMETER IN	D_o	2 79	2 79	2 79
INITIAL HEIGHT IN	H_o	6 30	6 30	6 38

CONTROLLED strain TEST





SPECIMEN NO		1	2	3
INITIAL: WATER CONTENT %	w_o	23 5	23 5	23 5
INITIAL: DRY DENSITY LB/CU FT	γ_o	98 1	98 2	97 4
INITIAL: SATURATION %	S_o	84 2	84 4	83 1
INITIAL: VOID RATIO	e_o	.781	.780	794
BEFORE SHEAR: WATER CONTENT %	w_c			
BEFORE SHEAR: DRY DENSITY LB/CU FT	γ_c			
BEFORE SHEAR: SATURATION %	S			
BEFORE SHEAR: VOID RATIO	e_c			
BEFORE SHEAR: FINAL BACK PRESSURE T/SQ FT	u_o			
MINOR PRINCIPAL STRESS T/SQ FT	σ_3	0.25	0 62	1.33
MAXIMUM DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{max}$			
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN	t_f			
ULTIMATE DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{ult}$			
Major Prin. Stress, TSF	σ_1	1 92	2 24	4 43
Pore Press. TSF	u	0 29	1 54	2 99

CONTROLLED strain TEST

DESCRIPTION OF SPECIMENS sandy CLAY (CL)

LL 34	PL 22	PI 12	Gs 2 80	TYPE OF SPECIMEN Remolded	TYPE OF TEST R

REMARKS *Stress @ 15% strain Specimens molded with -No 4 mat'l @ approximate water content of 23.1% (opt 12) and dry density of 97.9 PCF (95% of maximum density)

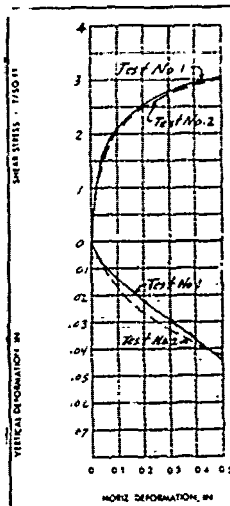
PROJECT Bernville Protective Works

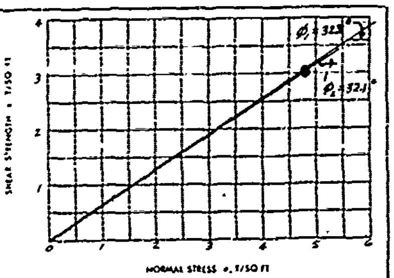
BORING NO SAT-19 SAMPLE NO S1, S2, S3, S4, S5

DEPTH/ELEV 10'-30'

LABORATORY NED DATE May 1974

TRIAXIAL COMPRESSION TEST REPORT





SHEAR STRENGTH PARAMETERS

φ = 32.1°

TAN φ = 0.627

c = 0.0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO		1	2		
INITIAL: WATER CONTENT	w_o	23 1 %	23 1 %	%	%
INITIAL: VOID RATIO	e_o	.785	.785		
INITIAL: SATURATION	S_o	82 %	82 %	%	%
INITIAL: DRY DENSITY LB/CU FT	γ_d	97 9	97 9		
VOID RATIO AFTER CONSOLIDATION	e_c	643	639		
TIME FOR 50 PERCENT CONSOLIDATION, MIN	t_{50}	0 5	0 6		
FINAL: WATER CONTENT	w_f	22 9 %	22 5 %	%	%
FINAL: VOID RATIO	e_f	495	.493		
FINAL: SATURATION	S_f	100 %	100 %	%	%
NORMAL STRESS T/SQ FT	σ	4 80	4 80		
MAXIMUM SHEAR STRESS T/SQ FT	τ_{max}	3 03*	3 01*		
ACTUAL TIME TO FAILURE, MIN	t_f	60.5	62 3		
RATE OF STRAIN, IN/MIN		0 0083	0 0080		
ULTIMATE SHEAR STRESS T/SQ FT	τ_u	—	—		

TYPE OF SPECIMEN Remolded	3.0 IN SQUARE		0.53 IN THICK
CLASSIFICATION sandy CLAY (CL)			
LL 34	PL 22	PI 12	Gs 2 80

REMARKS *Stress @ 5% deformation Specimens molded with -No 4 mat'l @ approx water content of 23.1% (opt 12%) and approx dry density of 97.9 PCF (95% of max. density).

PROJECT Bernville Protective Works

AREA Borrow Area ALPHA

BORING NO SAT-19 SAMPLE NO S1, S2, S3, S4, S5

DEPTH 10'-30' DATE May 1974

DIRECT SHEAR TEST REPORT

S TEST
INDEX NO. 16

Note
1 Refer to plate A-5 for lab test summary

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

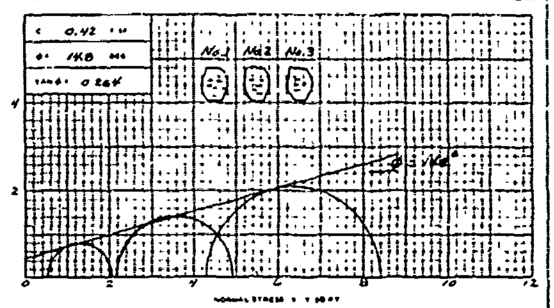
BLUE MARSH LAKE

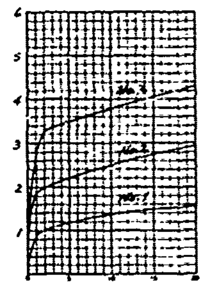
BERNVILLE PROTECTIVE WORKS

IMPERVIOUS FILL
SAT-19

SHEAR TEST REPORTS

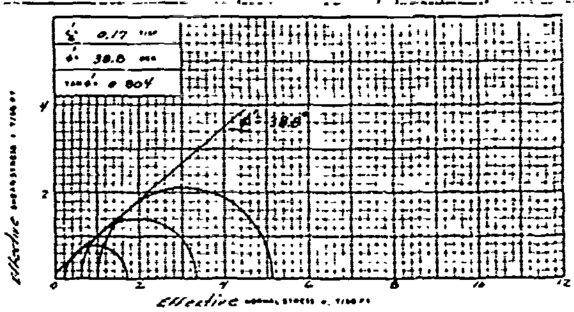
Left report (R test, total and effective stress)

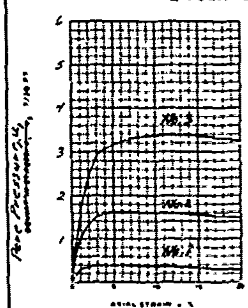




SPECIMEN NO.		1	2	3
INITIAL: WATER CONTENT %	w_o	13.8	13.9	13.6
INITIAL: DRY DENSITY LB/CU FT	γ_o	109.8	109.5	109.8
INITIAL: SATURATION %	S_o	68	68	67
INITIAL: VOID RATIO	e_o	.558	.561	.557
BEFORE SHEAR: WATER CONTENT %	w_c	19.9	18.7	17.3
BEFORE SHEAR: DRY DENSITY LB/CU FT	γ_c	110.6	113.0	.6.0
BEFORE SHEAR: SATURATION %	S_c	100	100	100
BEFORE SHEAR: VOID RATIO	e_c	.546	.513	.474
BEFORE SHEAR: FINAL BACK PRESSURE T/SQ FT	u_o	7.20	7.20	7.20
MINOR PRINCIPAL STRESS T/SQ FT	σ_3	0.54	2.16	4.32
MAXIMUM DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{max}$	1.4*	2.74*	4.10*
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN	t_f	90	90	90
ULTIMATE DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{ult}$	—	—	—
INITIAL DIAMETER IN	D_o	5.83	5.83	5.83
INITIAL HEIGHT IN	H_o	13.46	13.46	13.46

CONTROLLED strain TEST





SPECIMEN NO.		1	2	3
INITIAL: WATER CONTENT %	w_o	13.8	13.9	13.6
INITIAL: DRY DENSITY LB/CU FT	γ_o	109.8	109.5	109.8
INITIAL: SATURATION %	S_o			
INITIAL: VOID RATIO	e_o			
BEFORE SHEAR: WATER CONTENT %	w_c			
BEFORE SHEAR: DRY DENSITY LB/CU FT	γ_c			
BEFORE SHEAR: SATURATION %	S_c			
BEFORE SHEAR: VOID RATIO	e_c			
BEFORE SHEAR: FINAL BACK PRESSURE T/SQ FT	u_o			
MINOR PRINCIPAL STRESS T/SQ FT	$\bar\sigma_3$	0.23	0.61	1.00
MAXIMUM DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{max}$			
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN	t_f			
ULTIMATE DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{ult}$			
Max. Prin. Stress, TSF	$\bar\sigma_1$	1.70	3.35	5.10
Pore Pressure, TSF	u	0.31	1.55	2.32

CONTROLLED strain TEST

DESCRIPTION OF SPECIMEN clayey sandy GRAVEL (GP-GC)
+#4 mat'l consists essentially of shale which broke down during molding

LL 38 | PL 25 | PI 13 | Gs 2.74 | TYPE OF SPECIMEN Remolded | TYPE OF TEST R

REMARKS *Stress@15% strain. Specimens molded with -3/4" mat'l, with proportionate replacement for +3/4" using No.4 to 3/4" mat'l @ approx. water content of 13% (opt.-2%) and approx. dry density of 113.4 pcf (95% of max density)

PROJECT Bernville Protective Works

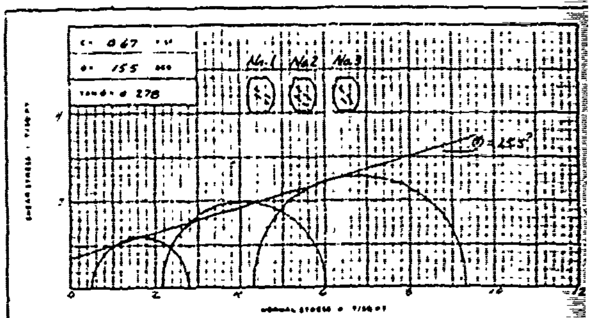
BORING NO. SAT-13 | SAMPLE NO. S-2

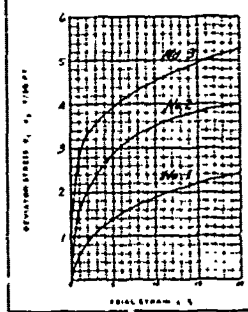
DEPTH/ELEV 1.8'-11.5'

LABORATORY NED | DATE May 1974

TRIAXIAL COMPRESSION TEST REPORT

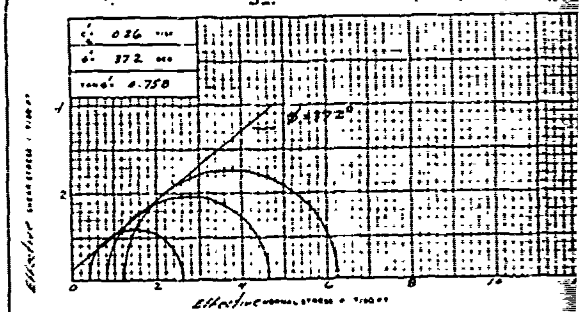
Right report (R test, total and effective stress)

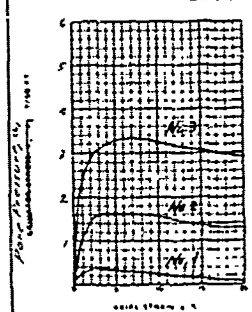




SPECIMEN NO.		1	2	3
INITIAL: WATER CONTENT %	w_o	18.1	16.7	17.9
INITIAL: DRY DENSITY LB/CU FT	γ_o	109.4	110.8	110.4
INITIAL: SATURATION %	S_o	88	84	89
INITIAL: VOID RATIO	e_o	.563	.543	.549
BEFORE SHEAR: WATER CONTENT %	w_c	19.9	19.5	17.4
BEFORE SHEAR: DRY DENSITY LB/CU FT	γ_c	110.7	111.5	115.8
BEFORE SHEAR: SATURATION %	S_c	100	100	100
BEFORE SHEAR: VOID RATIO	e_c	.545	.534	.477
BEFORE SHEAR: FINAL BACK PRESSURE T/SQ FT	u_o	7.20	7.20	7.80
MINOR PRINCIPAL STRESS T/SQ FT	σ_3	0.54	2.16	4.32
MAXIMUM DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{max}$	2.22*	3.82*	4.96*
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN	t_f	90	90	90
ULTIMATE DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{ult}$	—	—	—
INITIAL DIAMETER IN	D_o	5.83	5.83	5.83
INITIAL HEIGHT IN	H_o	13.46	13.46	13.46

CONTROLLED strain TEST





SPECIMEN NO.		1	2	3
INITIAL: WATER CONTENT %	w_o	18.1	16.7	17.9
INITIAL: DRY DENSITY LB/CU FT	γ_o	109.4	110.8	110.4
INITIAL: SATURATION %	S_o			
INITIAL: VOID RATIO	e_o			
BEFORE SHEAR: WATER CONTENT %	w_c			
BEFORE SHEAR: DRY DENSITY LB/CU FT	γ_c			
BEFORE SHEAR: SATURATION %	S_c			
BEFORE SHEAR: VOID RATIO	e_c			
BEFORE SHEAR: FINAL BACK PRESSURE T/SQ FT	u_o			
MINOR PRINCIPAL STRESS T/SQ FT	$\bar\sigma_3$	0.40	0.83	1.27
MAXIMUM DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{max}$			
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN	t_f			
ULTIMATE DEVIATOR STRESS T/SQ FT	$(\sigma_1-\sigma_3)_{ult}$			
Max. Prin. Stress, TSF	$\bar\sigma_1$	2.62	4.65	6.23
Pore Pressure, TSF	u	0.14	1.33	3.05

CONTROLLED strain TEST

DESCRIPTION OF SPECIMEN clayey sandy GRAVEL (GP-GC)
+#4 mat'l consists essentially of shale which broke down during molding

LL 38 | PL 25 | PI 13 | Gs 2.74 | TYPE OF SPECIMEN Remolded | TYPE OF TEST R

REMARKS *Stress@15% strain. Specimens molded with -3/4" mat'l, with proportionate replacement for +3/4" using No.4 to 3/4" mat'l, approx. water content of 15% (opt.) (13%) and approx. dry density of 113.4 pcf. (95% of max density)

PROJECT Bernville Protective Works

BORING NO. SAT-13 | SAMPLE NO. S-2

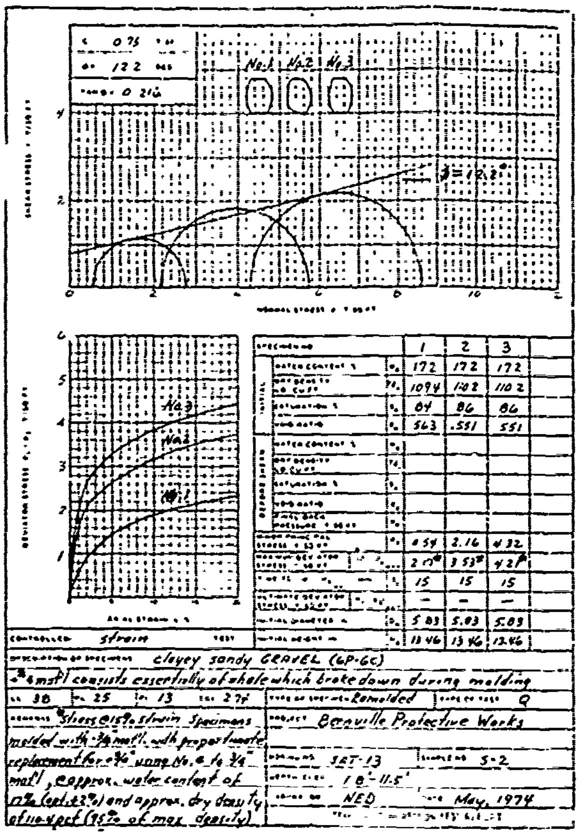
DEPTH/ELEV 1.8'-11.5'

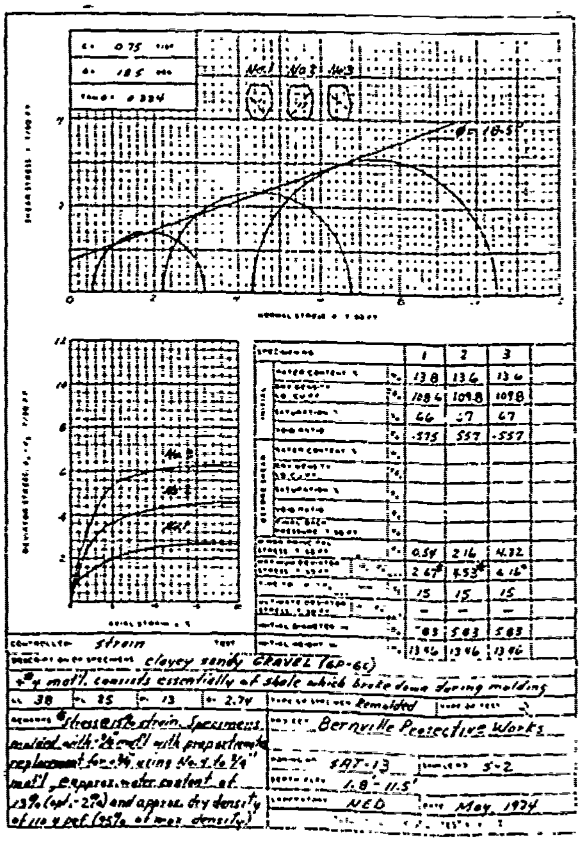
LABORATORY NED | DATE May 1974

TRIAXIAL COMPRESSION TEST REPORT

R & R̄ TESTS

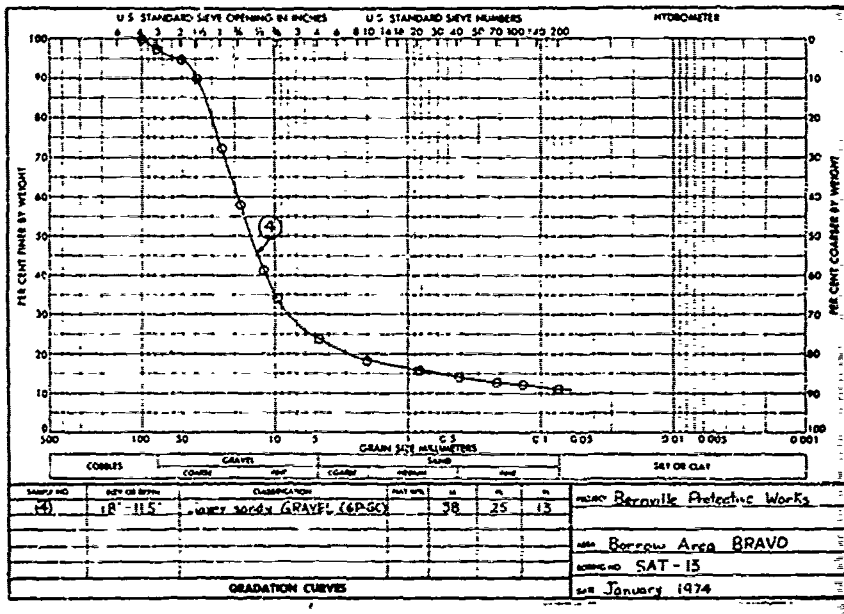
INDEX NO. 4





Q TESTS

INDEX NO. 4



Note:
1 Refer to plate A-5 for lab test summary.

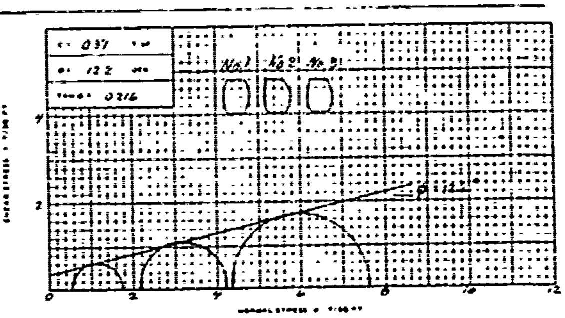
SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

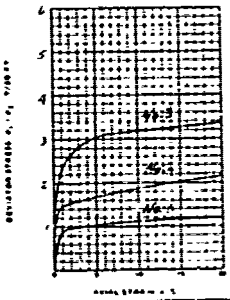
BLUE MARSH LAKE

BERNVILLE PROTECTIVE WORKS

RANDOM FILL
SAT-13

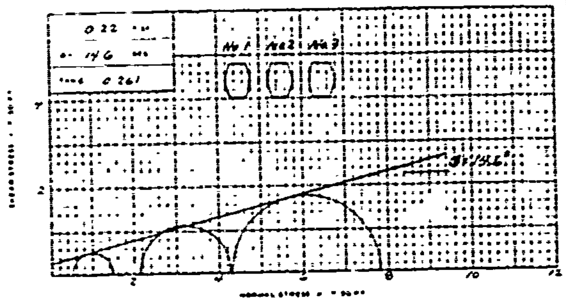
SHEAR TEST REPORTS

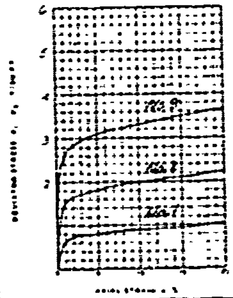




Specimen No.		1	2	3	
Initial: Water content %	w_o	16.0	16.2	16.2	
Dry density lb/cu ft	γ_d	103.5	103.4	103.4	
Saturation %	S_o	65	66	66	
Void ratio	e_o	.680	.690	.690	
Before test: Water content %	w_c	24.8	23.3	22.6	
Dry density lb/cu ft	γ_d	103.9	105.7	107.1	
Saturation %	S	100	100	100	
Void ratio	e_c	.676	.653	.631	
Back pressure	u_o	7.20	7.20	7.20	
Minor principal stress	σ_3	0.54	2.16	4.32	
Maximum deviator stress		1.10	2.03	3.27	
Time to failure	t_f	90	90	90	
Ultimate deviator stress		—	—	—	
Initial diameter in	D_o	5.83	5.83	5.83	
Initial height in	H_o	13.46	13.46	13.46	

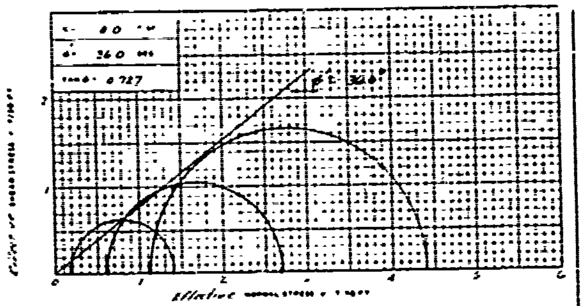
Controlled strain test

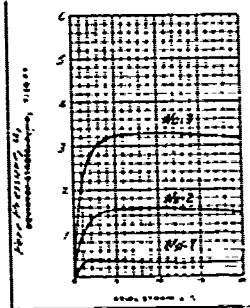




Specimen No.		1	2	3	
Initial: Water content %	w_o	20.0	20.0	20.0	
Dry density lb/cu ft	γ_d	103.5	103.5	103.5	
Saturation %	S_o	81	81	81	
Void ratio	e_o	.688	.688	.688	
Before test: Water content %	w_c	25.3	23.5	21.8	
Dry density lb/cu ft	γ_d	104.0	105.3	108.5	
Saturation %	S	100	100	100	
Void ratio	e_c	.680	.655	.610	
Back pressure	u_o	7.20	7.20	7.20	
Minor principal stress	σ_3	0.54	2.16	4.32	
Maximum deviator stress		.94	2.08	3.48	
Time to failure	t_f	90	90	90	
Ultimate deviator stress		—	—	—	
Initial diameter in	D_o	5.83	5.83	5.83	
Initial height in	H_o	13.46	13.46	13.46	

Controlled strain test





Specimen No.		1	2	3	
Initial: Water content %	w_o	16.0	16.2	16.2	
Dry density lb/cu ft	γ_d	103.5	103.4	103.4	
Saturation %	S_o	65	66	66	
Void ratio	e_o	.688	.690	.690	
Before test: Water content %	w_c				
Dry density lb/cu ft	γ_d				
Saturation %	S				
Void ratio	e_c				
Back pressure	u_o				
Minor principal stress	σ_3	0.19	0.63	1.11	
Maximum deviator stress					
Time to failure	t_f				
Ultimate deviator stress					
Max. Prin. Stress Tsf		1.37	2.46	4.78	
Pore Press. Tsf		0.35	1.53	3.21	

Controlled strain test

Description of specimens: clayey silty sandy GRAVEL (GM-GC)

LL 35 PL 25 PI 10 Gs 2.80 | Type of specimen: Remolded | Type of test: R

Remarks: Stress @ 15% strain Specimens molded with -3/4" mat'l with proportionate replacement for +3/4" using No.4 to 3/4" mat'l @ approx. water content of 16.0% (opt. 22%) and approx. dry density of 103.5 pcf (95% of max den.)

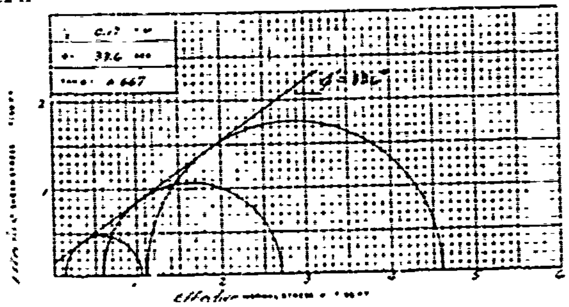
Project: Bernville Protective Works

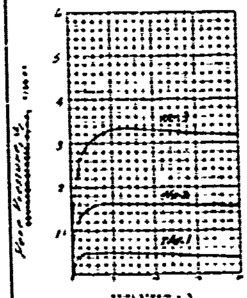
Boring No. SAT-19 | Sample No. 14, 13 30, 59 510

Depth/Elev. 5.0'-10.0'

Laboratory NED | Date May 1974

TRIAXIAL COMPRESSION TEST REPORT





Specimen No.		1	2	3	
Initial: Water content %	w_o	20.0	20.0	20.0	
Dry density lb/cu ft	γ_d	103.5	103.5	103.5	
Saturation %	S_o	81	81	81	
Void ratio	e_o	.688	.688	.688	
Before test: Water content %	w_c				
Dry density lb/cu ft	γ_d				
Saturation %	S				
Void ratio	e_c				
Back pressure	u_o				
Minor principal stress	σ_3	0.12	0.59	1.1	
Maximum deviator stress					
Time to failure	t_f				
Ultimate deviator stress					
Max. Prin. Stress Tsf		1.06	2.67	4.59	
Pore Press. Tsf		0.42	1.57	3.21	

Controlled strain test

Description of specimens: clayey silty sandy GRAVEL (GM-GC)

LL 35 PL 25 PI 10 Gs 2.80 | Type of specimen: Remolded | Type of test: R

Remarks: Stress @ 15% strain Specimens molded with -3/4" mat'l with proportionate replacement for +3/4" using No.4 to 3/4" mat'l @ approx. water content of 20% (opt. 22%) and approx. dry density of 103.5 pcf (95% of max den.)

Project: Bernville Protective Works

Boring No. SAT-19 | Sample No. 14, 13 30, 59 510

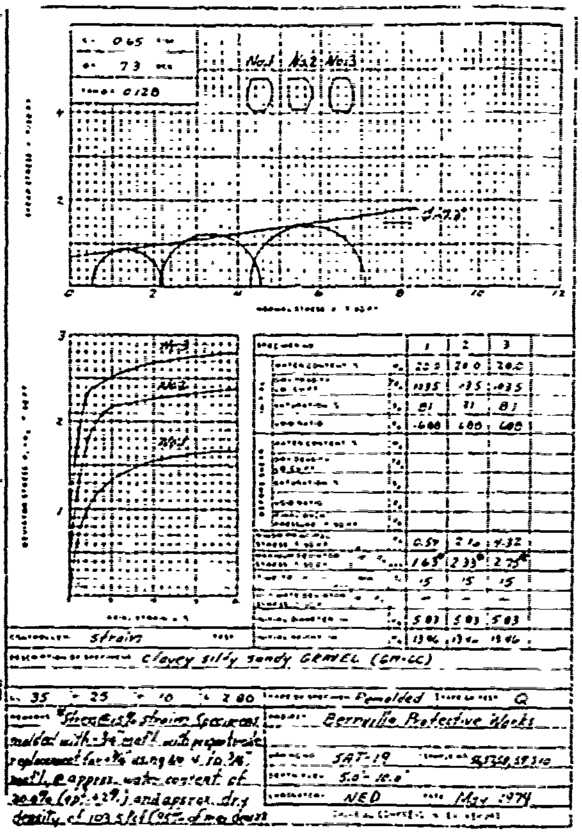
Depth/Elev. 5.0'-10.0'

Laboratory NED | Date May 1974

TRIAXIAL COMPRESSION TEST REPORT

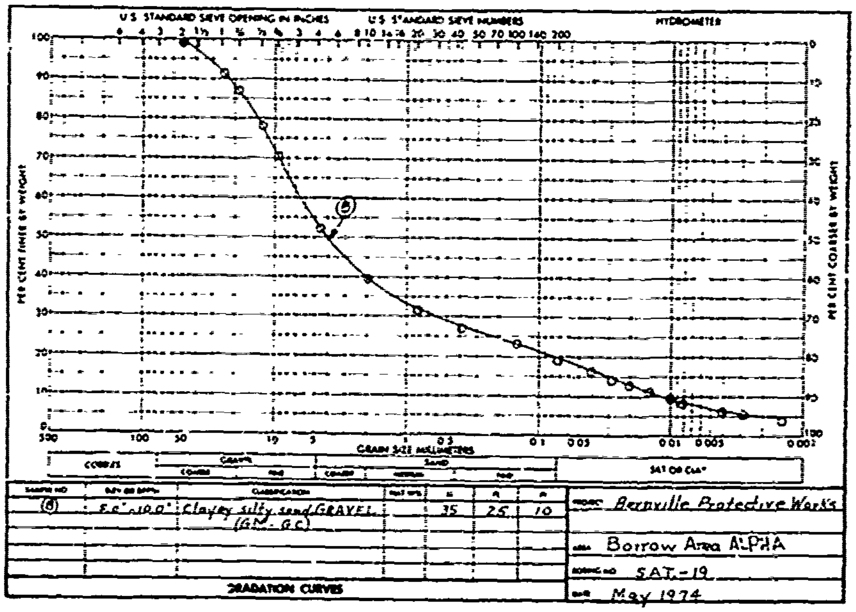
R&R TESTS

INDEX NO. 8



Q TEST

INDEX NO. 8



Note
1 Refer to plate A-5 for lab test summary.

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

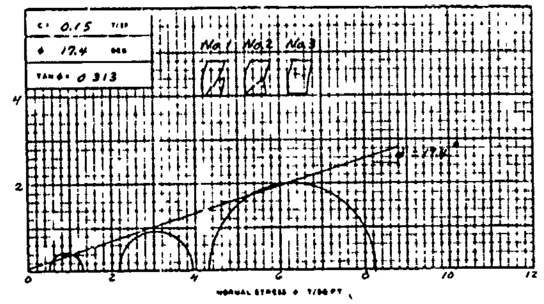
BLUE MARSH LAKE

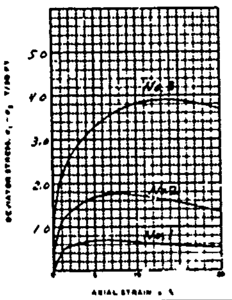
BERNVILLE PROTECTIVE WORKS

RANDOM FILL
SAT-19

SHEAR TEST REPORTS

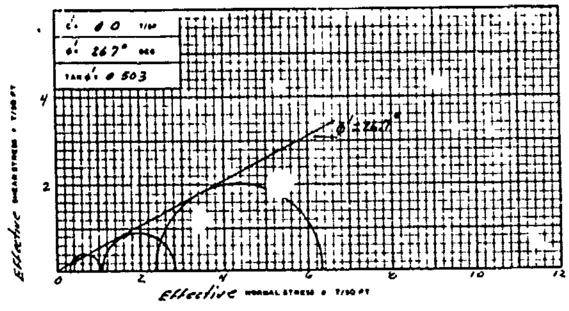
D.M. NO. 13 PLATE A

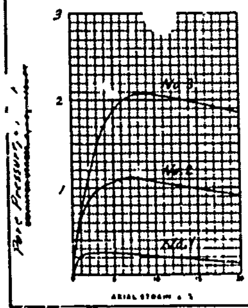




SPECIMEN NO			1	2	3	
INITIAL	WATER CONTENT %	w_o	26 1	27 6	26 8	
	DRY DENSITY LB CU FT	γ_{d_o}	96 1	99 0	96 4	
	SATURATION %	S_o	94 0	94.5	97 2	
	VOID RATIO	e_o	0 746	0.786	0 741	
BEFORE SHEAR	WATER CONTENT %	w_c	25 9	24.3	22 8	
	DRY DENSITY LB CU FT	γ_{d_c}	99 0	101 5	108 1	
	SATURATION %	S_c	100	100	100	
	VOID RATIO	e_c	0.696	0 653	0.612	
	FINAL BACK PRESSURE T SQ FT	u_o	7 20	7 20	7 20	
MINOR PRINCIPAL STRESS T SQ FT		σ_3	0 54	2 16	4 32	
MAXIMUM DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{max}$	0.67	1 78	3 93	
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN		t_f	40 6	48 0	85.0	
ULTIMATE DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{ult}$	0.60*	1 57*	3 90*	
INITIAL DIAMETER, IN		D_o	1 43	1 42	1 42	
INITIAL HEIGHT IN		H_o	3 18	3 16	3.16	

CONTROLLED strain TEST





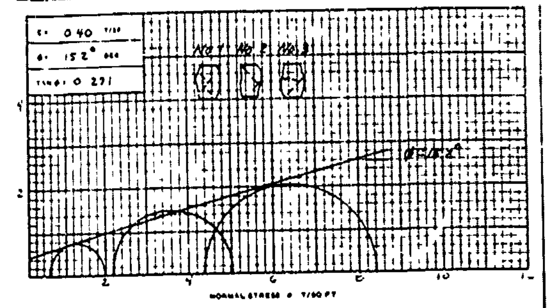
SPECIMEN NO			1	2	3	
INITIAL	WATER CONTENT %	w_o				
	DRY DENSITY LB CU FT	γ_{d_o}				
	SATURATION %	S_o				
	VOID RATIO	e_o				
BEFORE SHEAR	WATER CONTENT %	w_c				
	DRY DENSITY LB CU FT	γ_{d_c}				
	SATURATION %	S_c				
	VOID RATIO	e_c				
	FINAL BACK PRESSURE T SQ FT	u_o				
MINOR PRINCIPAL STRESS T SQ FT		σ_3				
MAXIMUM DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{max}$	0 30	1 06	2 37	
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN		t_f				
ULTIMATE DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{ult}$				
~~INITIAL DIAMETER~~ Maj Prin Stress, Tsf		$\bar{\sigma}_1$	0.97	2 83	6 30	
~~INITIAL HEIGHT~~ Pore Press, u, Tsf		$\bar{u}$	0 24	1.10	1 96	

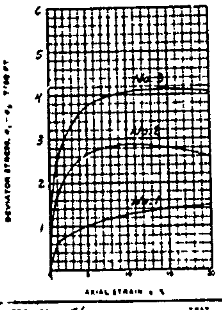
CONTROLLED strain TEST

DESCRIPTION OF SPECIMENS Blue CLAY (CL)

LL 48	PL 23	PI 25	G 2 69	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST R_1
REMARKS Major Principal Stress and Pore Pressure selected @ Maximum Deviator Stress.				PROJECT Bernville Protective Works	
				BORING NO SAB - 214	SAMPLE NO U 2
				DEPTH ELEV 4.0'-6.0'	
				LABORATORY NED	DATE January, 1974
See Sheet 1 of 2				TRIAXIAL COMPRESSION TEST REPORT	

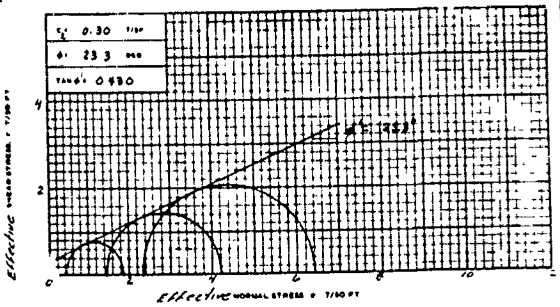
INDEX DESIGN. B

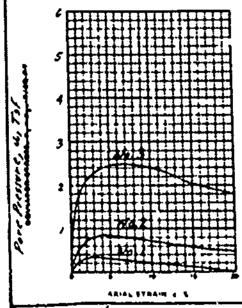




SPECIMEN NO			1	2**	3	
INITIAL	WATER CONTENT %	w_o	24 2	18.1	26 6	
	DRY DENSITY LB CU FT	γ_{d_o}	98 5	104 6	94.9	
	SATURATION %	S_o	90 5	78 8	91 3	
	VOID RATIO	e_o	0 730	0 628	0 795	
BEFORE SHEAR	WATER CONTENT %	w_c	25 4	19 3	23 2	
	DRY DENSITY LB/CU FT	γ_{d_c}	100.5	111 5	104.2	
	SATURATION %	S_c	100	100	100	
	VOID RATIO	e_c	0.694	0 528	0.634	
	FINAL BACK PRESSURE T/SQ FT	u_o	7.20	7 20	7 20	
MINOR PRINCIPAL STRESS T SQ FT		σ_3	0 54	2 16	4 32	
MAXIMUM DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{max}$	1 40*	2 86	4.08*	
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN		t_f	90	52	90	
ULTIMATE DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{ult}$	—	2.78*	—	
INITIAL DIAMETER IN		D_o	1 43	1 43	1 43	
INITIAL HEIGHT IN		H_o	3.14	3.11	3.12	

CONTROLLED Strain TEST





SPECIMEN NO			1	2	3	
INITIAL	WATER CONTENT %	w_o				
	DRY DENSITY LB CU FT	γ_{d_o}				
	SATURATION %	S_o				
	VOID RATIO	e_o				
BEFORE SHEAR	WATER CONTENT %	w_c				
	DRY DENSITY LB CU FT	γ_{d_c}				
	SATURATION %	S_c				
	VOID RATIO	e_c				
	FINAL BACK PRESSURE T/SQ FT	u_o				
MINOR PRINCIPAL STRESS T/SQ FT		σ_3	0 44	1 42	2 32	
MAXIMUM DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{max}$				
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN		t_f				
ULTIMATE DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{ult}$				
Maj Prin Stress Tsf		$\bar{\sigma}_1$	1.84*	4 28	6 40*	
Pore Press u Tsf		$\bar{u}$	0.10*	0.74	2.00*	

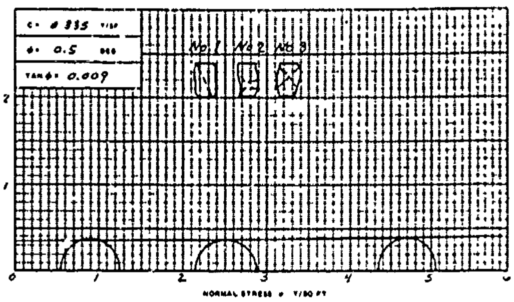
CONTROLLED strain TEST

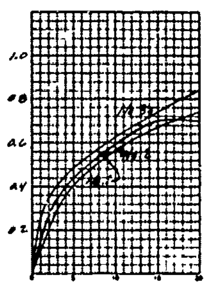
DESCRIPTION OF SPECIMENS Blue and red CLAY (CL) with medium to fine sand pockets

LL 42	PL 23	PI 19	G 2 73	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST R_2
REMARKS *Stress @ 5% strain **Sample No. 2 contained more sand than other samples.				PROJECT Bernville Protective Works	
				BORING NO SAB-214	SAMPLE NO U-2
				DEPTH ELEV 4.0'-6.0'	
				LABORATORY NED	DATE January 1974
See Sheet 2 of 2				TRIAXIAL COMPRESSION TEST REPORT	

INDEX DESIGN. C

R&R̄ TESTS





SPECIMEN NO			1	2	3
INITIAL	WATER CONTENT %	w_o	26.5	26.4	26.2
	DRY DENSITY LB CU FT	γ_{d_o}	95.6	93.7	97.0
	SATURATION %	S_o	94.2	89.6	96.5
	VOID RATIO	e_o	0.755	0.791	0.730
BEFORE SHEAR	WATER CONTENT %	w_c	—	—	-
	DRY DENSITY LB CU FT	γ_{d_c}	—	—	—
	SATURATION %	S_c	—	—	—
	VOID RATIO	e_c	—	—	—
	FINAL BACK PRESSURE T/SQ FT	u_o	—	—	—
MINOR PRINCIPAL STRESS T SQ FT		σ_3	0.54	2.16	4.32
MAXIMUM DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{max}$	0.78*	0.68*	0.74*
TIME TO $(\sigma_1-\sigma_3)_{max}$ MIN		t_f	15	15	5
ULTIMATE DEVIATOR STRESS T SQ FT		$(\sigma_1-\sigma_3)_{ult}$	—	—	—
INITIAL DIAMETER IN		D_o	1.43	1.43	1.43
INITIAL HEIGHT IN		H_o	3.13	3.13	3.13

CONTROLLED strain TEST

DESCRIPTION OF SPECIMENS Blue CLAY (CL)

LL 48	PL 23	PI 25	Gs 2.69	TYPE OF SPECIMEN Undisturbed	TYPE OF TEST Q_1

REMARKS * Stress @ 15% strain

PROJECT Bernville Protective Works

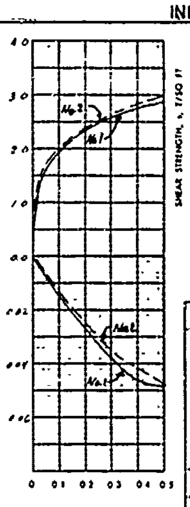
BORING NO SAB-21U SAMPLE NO U-2

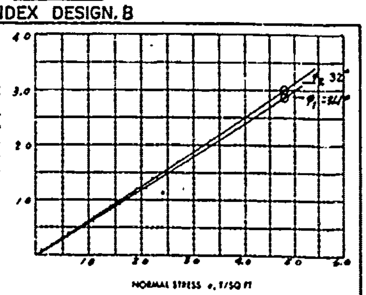
DEPTH ELEV 4.0'-6.0'

LABORATORY NED DATE January, 1974

TRIAXIAL COMPRESSION TEST REPORT

Q TEST
INDEX DESIGN. B





SHEAR STRENGTH PARAMETERS

φ = 31.1°

TAN φ = 0.602

c = 0.0 T/SQ FT

☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO			1	2		
INITIAL	WATER CONTENT	w_o	48.8%	45.1%	%	%
	VOID RATIO	e_o	1.312	1.172		
	SATURATION	S_o	99%	102%	%	%
	DRY DENSITY LB/CU FT	γ_d	71.8	76.4		
VOID RATIO AFTER CONSOLIDATION		e_c	0.812	1.023		
TIME FOR 50 PERCENT CONSOLIDATION, MIN		t_{50}	1.6	1.9		
FINAL	WATER CONTENT	w_f	32.7%	32.2%	%	%
	VOID RATIO	e_f	0.596	0.819		
	SATURATION	S_f	100%	100%	%	%
NORMAL STRESS, T/SQ FT		σ	4.80	4.80		
MAXIMUM SHEAR STRESS T/SQ FT		τ_{max}	2.89*	3.00*		
ACTUAL TIME TO FAILURE MIN		t_f	94	93		
RATE OF STRAIN, IN/MIN			0.0053	0.0054		
ULTIMATE SHEAR STRESS, T/SQ FT		τ_{ult}	—	—		

TYPE OF SPECIMEN Undisturbed 3.0 IN SQUARE 0.50 IN THICK

CLASSIFICATION Organic fine sandy CLAY (OH)

LL 63	PL 30	PI 33		Gs 2.66

REMARKS * Stress @ 0.5" deformation

PROJECT Bernville Protective Works

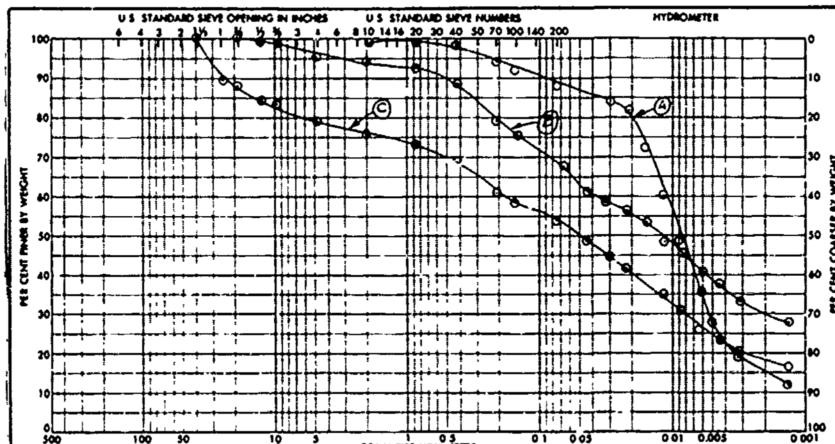
AREA

BORING NO SAB 21U SAMPLE NO U-1

DEPTH EL. 2.0'-4.0' DATE Jan. 1974

DIRECT SHEAR TEST REPORT

S TEST
INDEX DESIGN A



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SAMPLE NO	ELEV OR DEPTH	CLASSIFICATION	NAT W%	LL	PL	PI
A	2.0'-4.0'	Organic fine sandy CLAY (OH)		63	30	33
B	4.0-6.0	m-f sandy CLAY (CL)		48	23	25
C	4.0'-6.0	gravelly sandy CLAY (CL)		42	23	19

GRADATION CURVES

PROJECT Bernville Protective Works

AREA Levee Foundation

BORING NO SAB-21U

DATE Feb 1974

Note
1 Refer to plate A-6 for lab test summary.

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS

FOUNDATION MATERIAL
SAB-21

SHEAR TEST REPORTS

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PENNSYLVANIA
BLUE MARSH LAKE

DESIGN MEMORANDUM NO. 13
BERNVILLE PROTECTIVE WORKS

APPENDIX B
STABILITY ANALYSIS

SECTION 1

STABILITY ANALYSIS

B-1-01 GENERAL. The stability of the main levee has been analyzed by the Modified Swedish Method using WES computer programs 41-Z5-104G and 741-F5-E503B. Occasional manual checks to verify the computer results were made and the checking reflected reasonable agreement. The critéria and methods used, with one exception, are in accordance with EM 1110-2-1902, "Stability of Earth and Rock-Fill Dams," dated 1 April 1970. The one departure from recommended criteria was to use a side earth force direction that was the average of the outer levee slope and the slope of the failure plane at the base of each slice. Previous experience has indicated unreasonable results are sometimes obtained when only the average outer slope direction is used for deep circular failure surfaces with short radii just above the embankment surface. Results of the stability studies are presented on plates B-1 through B-4.

B-1-02 DESIGN CASES AND ASSUMPTIONS. The following design cases to which the levee will be subjected were studied.

a. End of Construction. This case assumes the strength of the embankment and foundation materials as that value available under the conditions of instantaneous construction of the levee. "Q" strengths were used for slow draining soils and the phraetic surface was assumed at elevations that presently exist. Only the steeper 1V-on-2.5H landside slope was analyzed for end of construction condition.

b. Partial Pool. The riverside slope was studied for intermediate pool stages that allowed steady seepage condition to develop. The shear strengths used were from the intermediate envelope, (R+S)/2, when the R strength was less than the S strength, otherwise, the S strength was used. The levee was assumed fully saturated below pool levels that were varied until the critical pool elevation was bracketed.

c. Steady Seepage. The landside slope was analyzed for steady seepage condition using composite strength envelopes identical to values adopted for partial pool. The seepage li e was initially established for a reservoir pool at spillway crest elevation 307 and a homogeneous embankment except for the pervious zone provided to prevent seepage emergence on the landside slope face. Development of the steady seepage line from SPF elevation 317.5 shown on plates B3 and B4 was based on seepage velocity computations that indicated advancement of the upper phraetic surface through the impervious core would be less than 3 feet during the estimated four-day period where flows above spillway elevaton 307 would occur at Bernville. Assuming a homogeneous levee section in order to establish the seepage line, is conservative in view of the permeability test results presented on plate A-5 where the average random fill is shown to be many more times pervious than the impervious fill materials.

d. Sudden Drawdown. The riverside slope was analyzed for sudden drawdown in the portion (spillway crest elevation 307 to normal stream level) that is likely to become saturated. The shear strengths used were based on the minimum R or S envelopes. Sudden drawdown from Standard Project Flood Pool level 317.5 was not analyzed because computations which consider permeability coefficients of 10^{-4} cm/sec or less permeable values for random fill indicate infiltration would not be significant during the short period where pool levels would exist above spillway elevation 307. More permeable random materials if placed above elevation 307 could be expected to drain during drawdown. Under the sudden drawdown condition which was analyzed, the spillway pool was conservatively assumed to drawdown so rapidly from elevation 307 that the 1V-on-3H riverside slope below spillway level was left fully saturated. For the short section of 1V-on-2H riverside slope discussed in paragraph 4-05, the line of seepage was assumed at the base of the free draining outer rockfill zone.

e. Earthquake. The stability of the levee was analyzed for earthquake condition for each of the above conditions except sudden drawdown. In earthquake analysis, a horizontal seismic force equal to 0.05g was added to the other driving forces causing sliding.

B-1-03 DESIGN SHEAR STRENGTHS. The shear strength design values selected for the foundation and embankment materials are shown graphically on plate B-1. The adopted strengths are generally the lowest values obtained in testing of the respective materials. A conservative strength equivalent to the second lowest strength obtained on remolded highly weathered shale from borrow area Alpha was adopted for the dense in-situ foundation layer of highly weathered bedrock.

B-1-04 EMBANKMENT ANALYSES. The stability of the main levee was analyzed at a location of greatest embankment height over soil foundation layers that remain following removal of the upper, soft alluvial stratum. The steeper 1V-on-2H riverside slope with outer rockfill zone at station 16+70 was also analyzed. Stability summaries are presented on plates B-2 and B-3 with plate B-4 presenting a sample calculation for the steady seepage condition. The lowest factors of safety obtained are summarized in the following table:

TABLE B-1

LOWEST COMPUTED FACTORS OF SAFETY

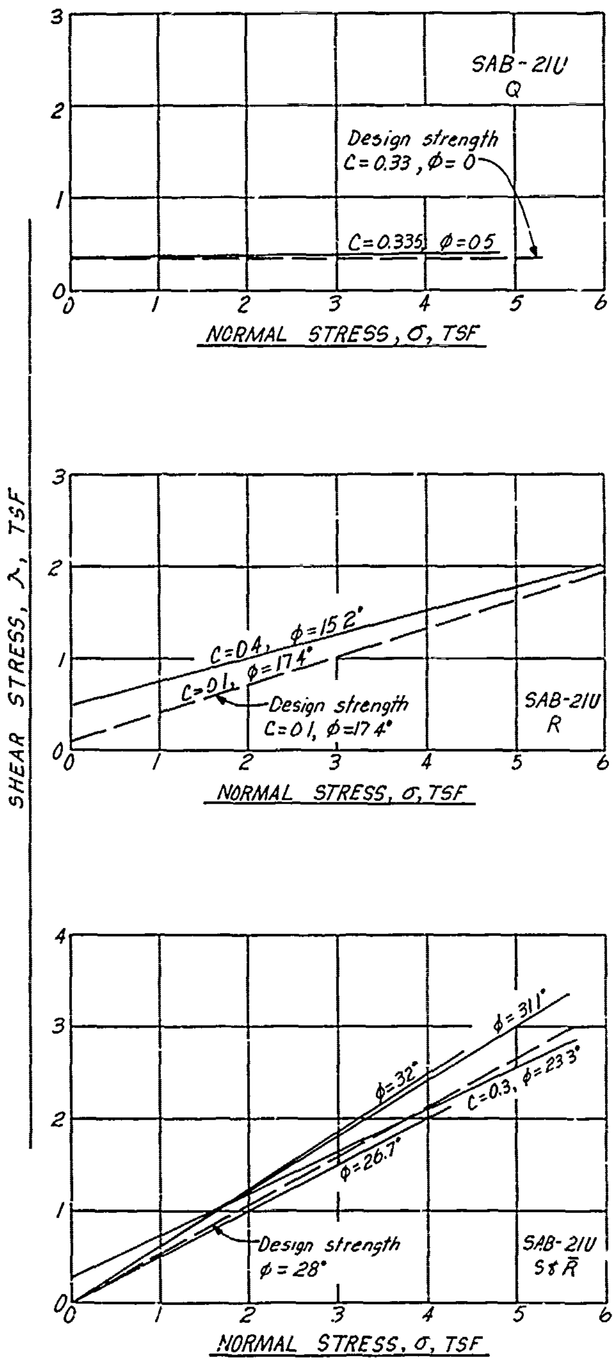
Case	Slope	Strength	F.S.	F.S. with earthquake condition
	1V on 2H Riverside		1.60	
Sudden Drawdown from el.307	1V on 3H Riverside	S or R	1.40	
	1V on 3H Riverside		1.65	1.38
Partial Pool	1V on 2H Riverside	S or $\frac{S+R}{2}$	1.50	1.30
After Construction	Landside	Q	2.17	1.86
Steady Seepage	Landside	S or $\frac{S+R}{2}$	1.50	1.30

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PENNSYLVANIA
BLUE MARSH LAKE

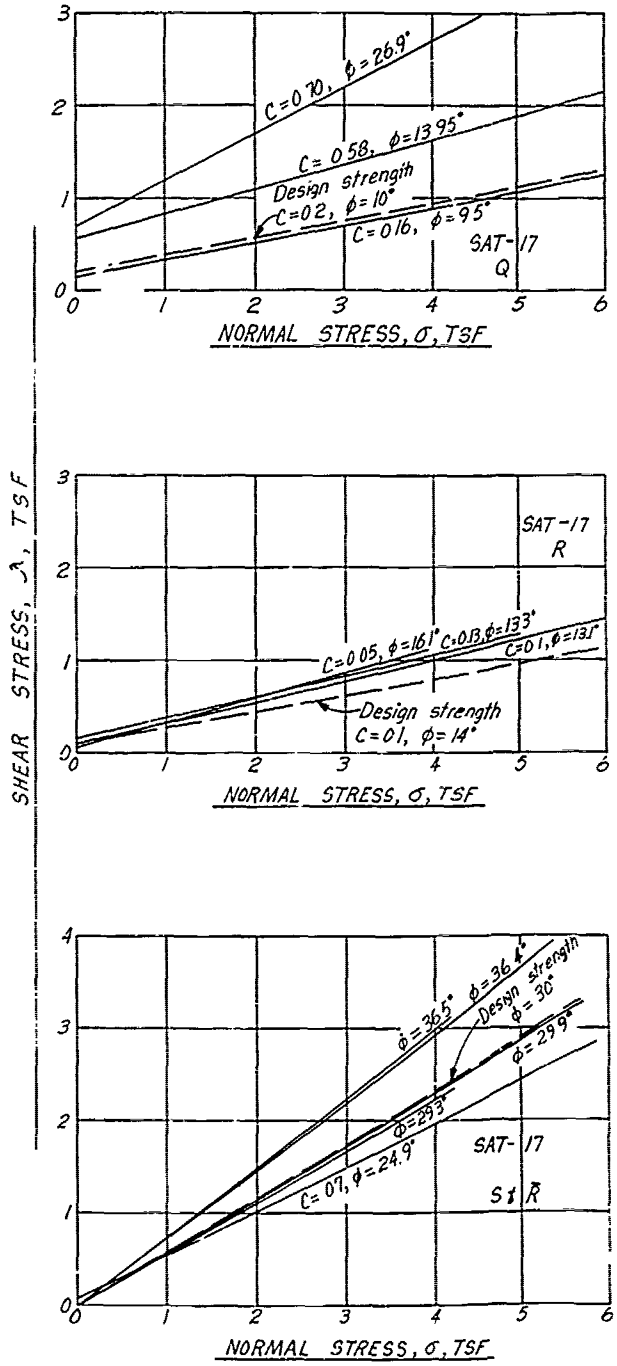
DESIGN MEMORANDUM NO. 13
BERNVILLE PROTECTIVE WORKS

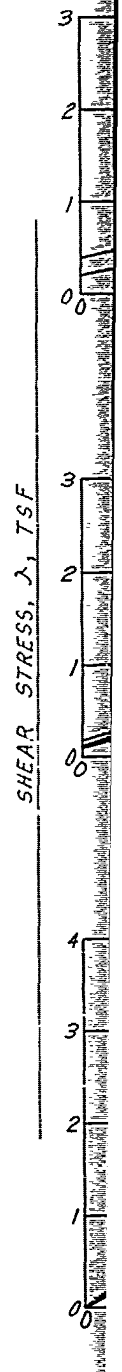
APPENDIX C
DESIGN CALCULATIONS

Structural Calculations
Mechanical Calculations

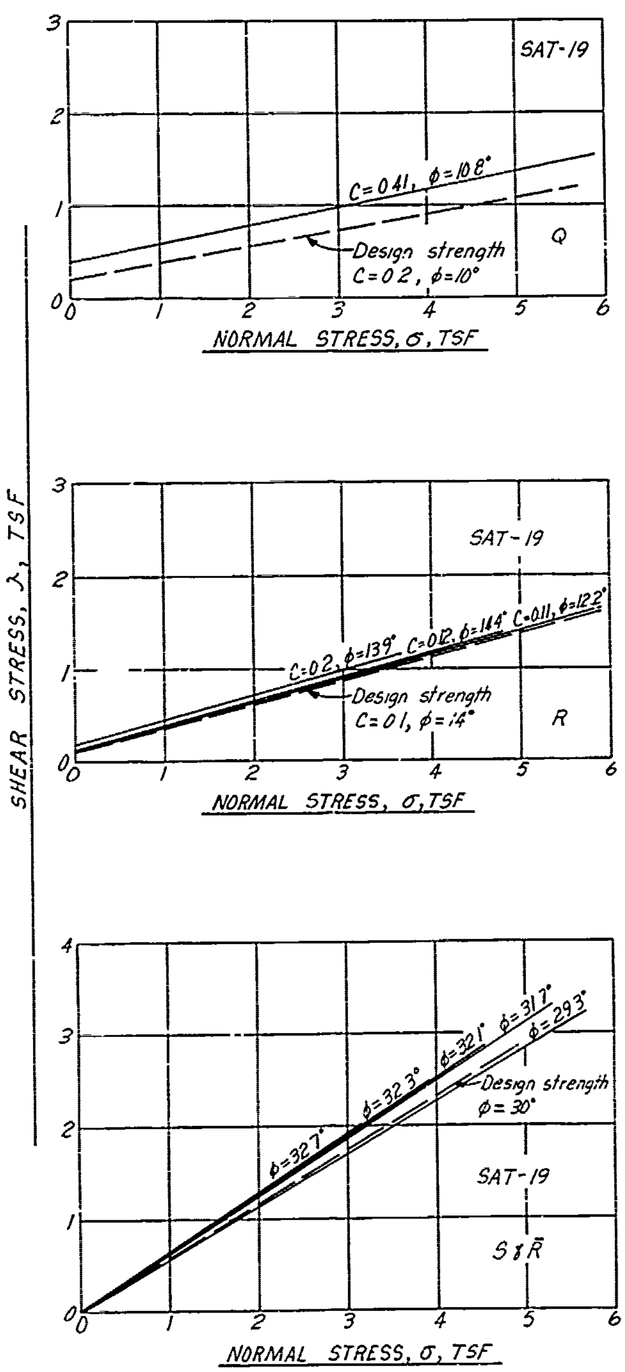


FOUNDATION - ZONE 3

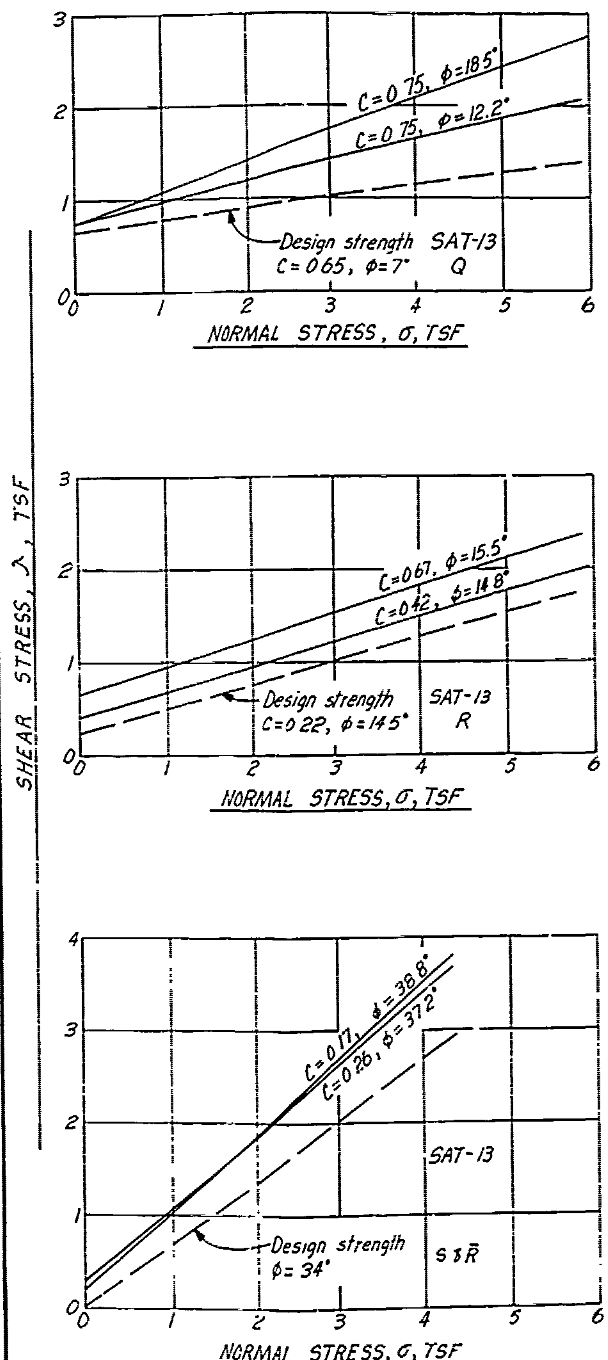


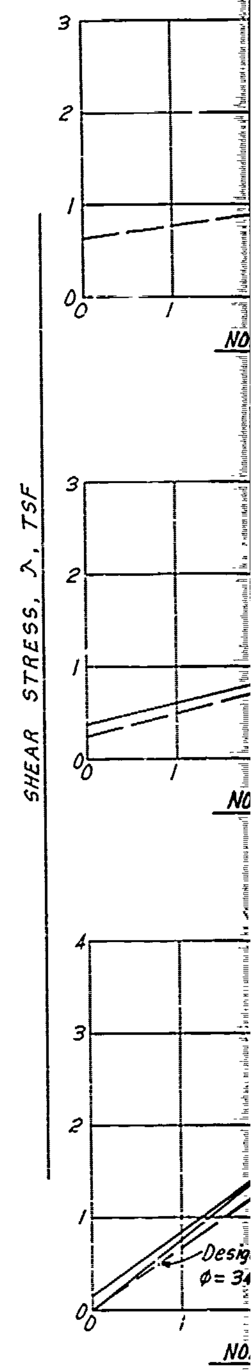


IMPERVIOUS FIL

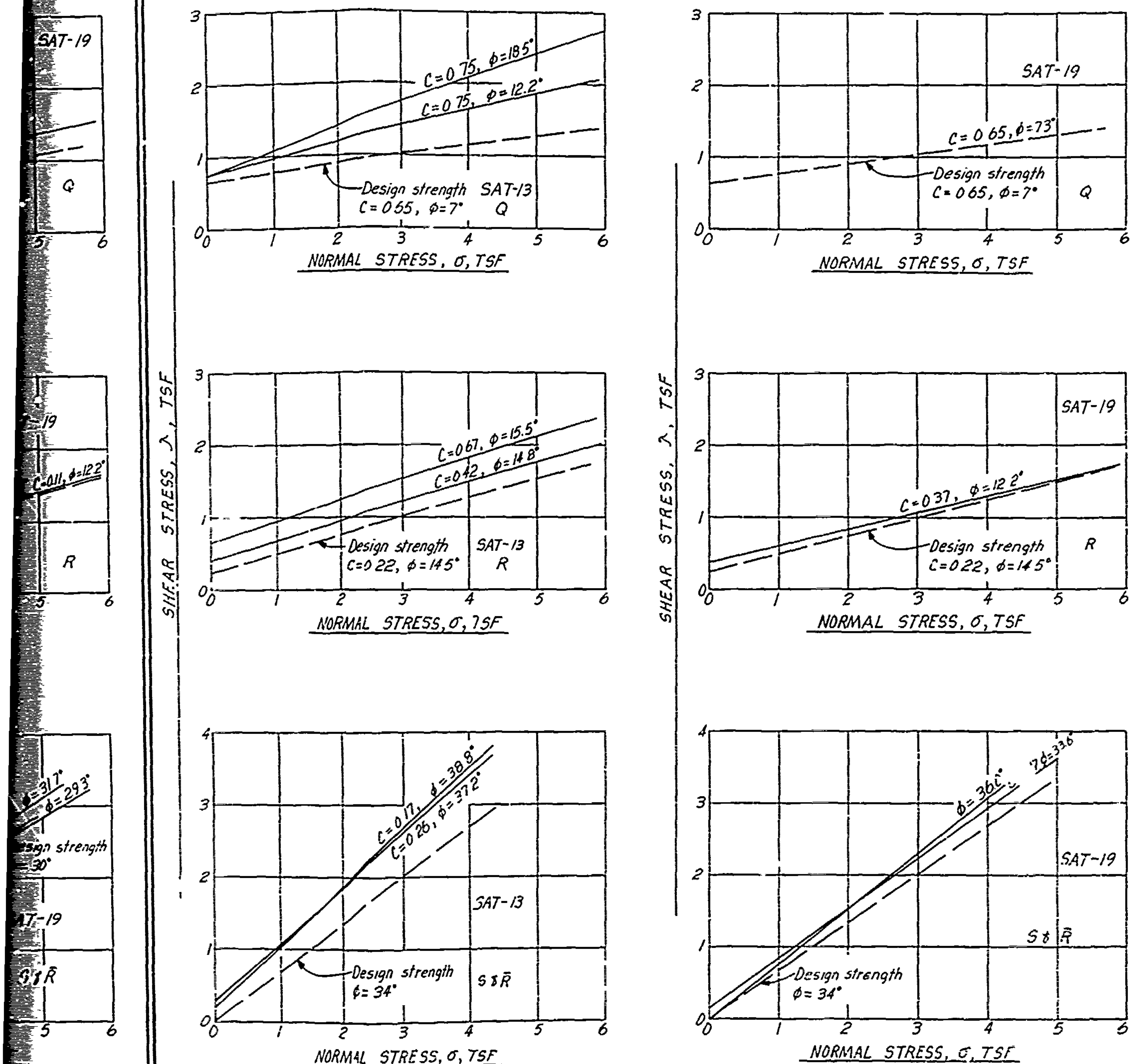


PERVIOUS FILL





RANDOM FILL



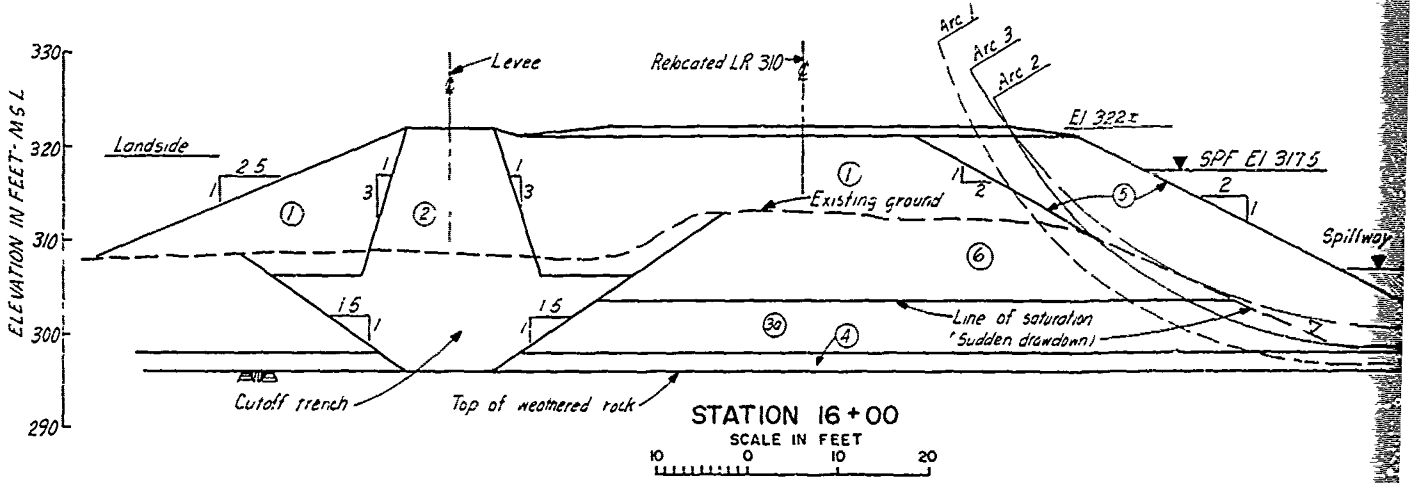
RANDOM FILL

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE

BERNVILLE PROTECTIVE WORKS

ADOPTED SHEAR STRENGTHS



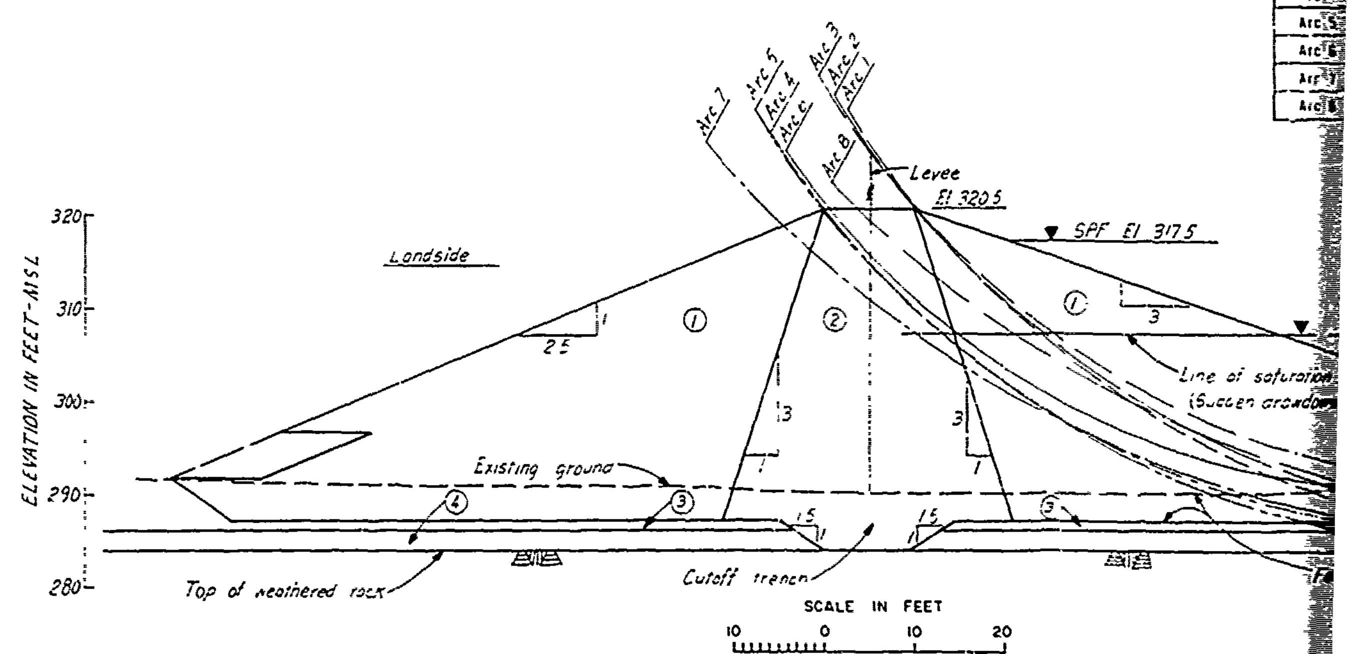
STATION 16 + 00

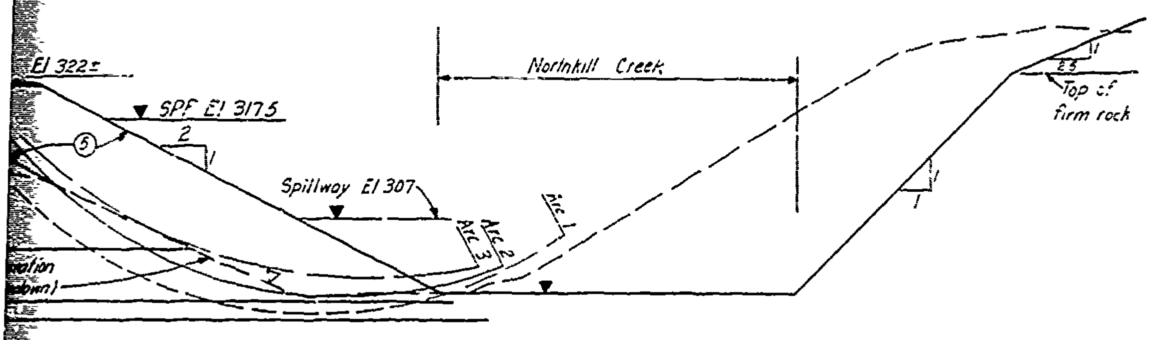
ADOPTED DESIGN VALUES

Zone	Description	Unit Wt (pcf)		"R" Strength		"S" Strength	(R+S)/2 Strength	
		γ m	γ s	φ (°)	C (psf)	φ °	φ (°)	C (psf)
1	Random Clayey silty sandy GRAVEL (GW-GC)	125	130	14.5	440	34	24.3	220
2	Impervious Gravelly clayey SAND (SC)	120	125	14	200	30	22	100
3a, 3	Gray SILT (ML) and Gray sandy CLAY w gravel (CL)	115	120	17.4	200	28	22.7	100
4	Highly weath shale in form of clayey sandy GRAVEL (GP GC) w some cobbles	125	130	14.5	800	34	24.3	400
5	Rockfill in form of poorly graded GRAVEL (GP)	125	130			34	34	
6	Poorly graded GRAVEL (GP) tr silt (GP GM)	125	130			34	34	

Sliding Surface
Arc 1
Arc 2
Arc 3

Sliding Surface
Arc 1
Arc 2
Arc 3
Arc 4
Arc 5
Arc 6
Arc 7
Arc 8





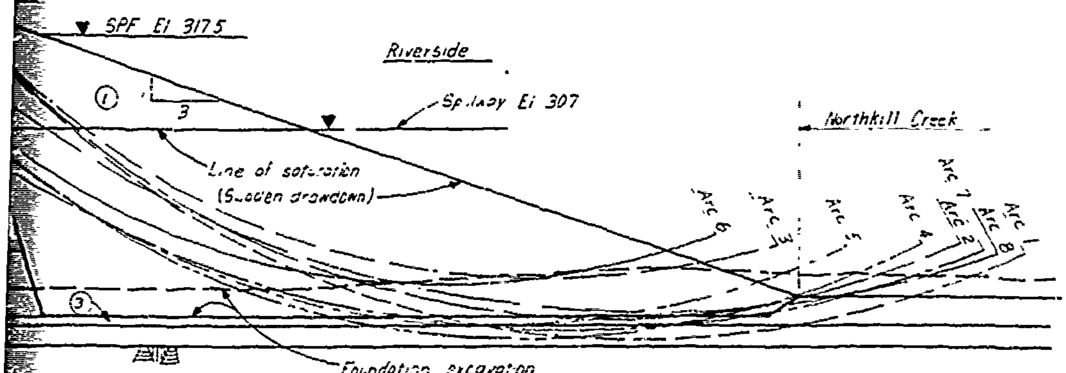
STATION 16+00 SAFETY FACTORS

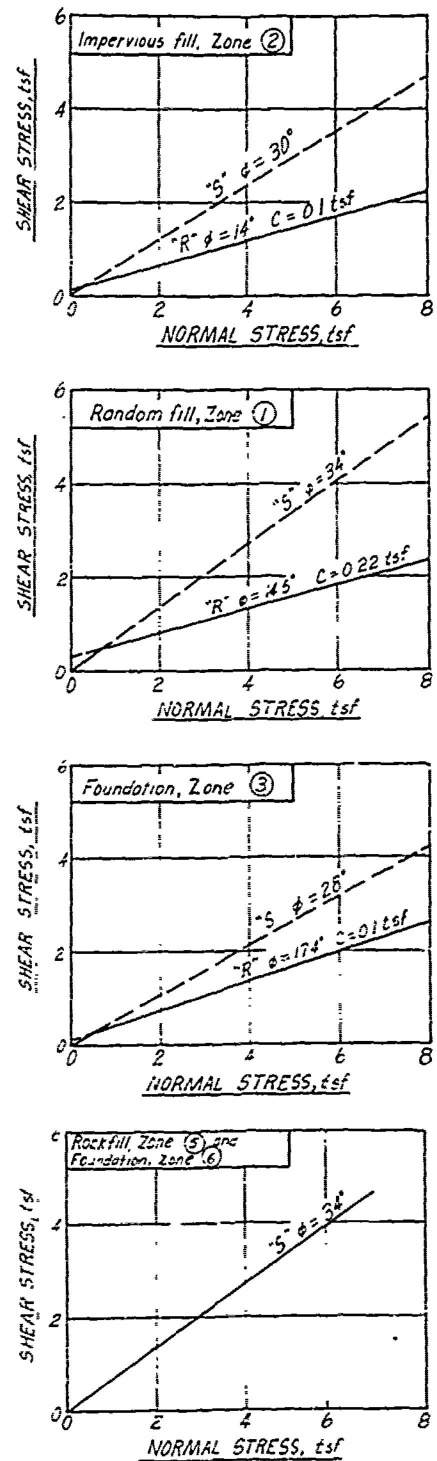
Sliding Surface	Radius (ft.)	Sudden Drawdown from El 307	Critical Pool El 305	Critical Pool + earthquake condition
Arc 1	49	1.70	1.50	1.30
Arc 2	49	1.30	1.60	1.40
Arc 3	58	1.60	1.50	1.40

...th
...(psf)
220
100
100
400
-
-

RIVERSIDE SAFETY FACTORS

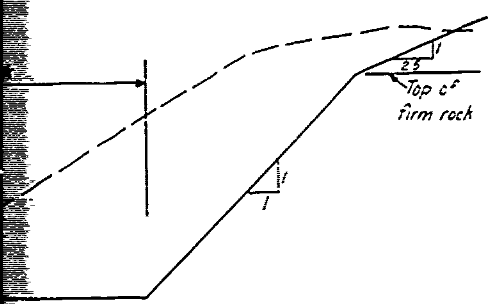
Sliding Surface	Radius (ft.)	Sudden Drawdown from El 307	Critical Pool El 300	Critical Pool + earthquake condition
Arc 1	101	1.45	1.90	1.50
Arc 2	97.5	1.45	1.75	1.40
Arc 3	90	1.55	1.80	1.50
Arc 4	56	1.47	1.75	1.44
Arc 5	22.5	1.40	1.55	1.35
Arc 6	85	1.55	1.85	1.55
Arc 7	124	1.50		
Arc 8	124	1.60		





STRENGTH ENVELOPES FOR SUDDEN DRAWDOWN CONDITION

20

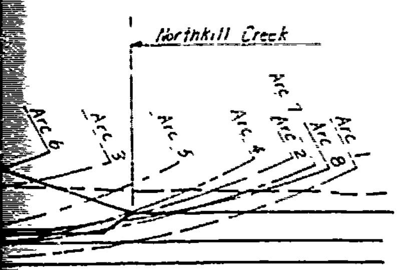


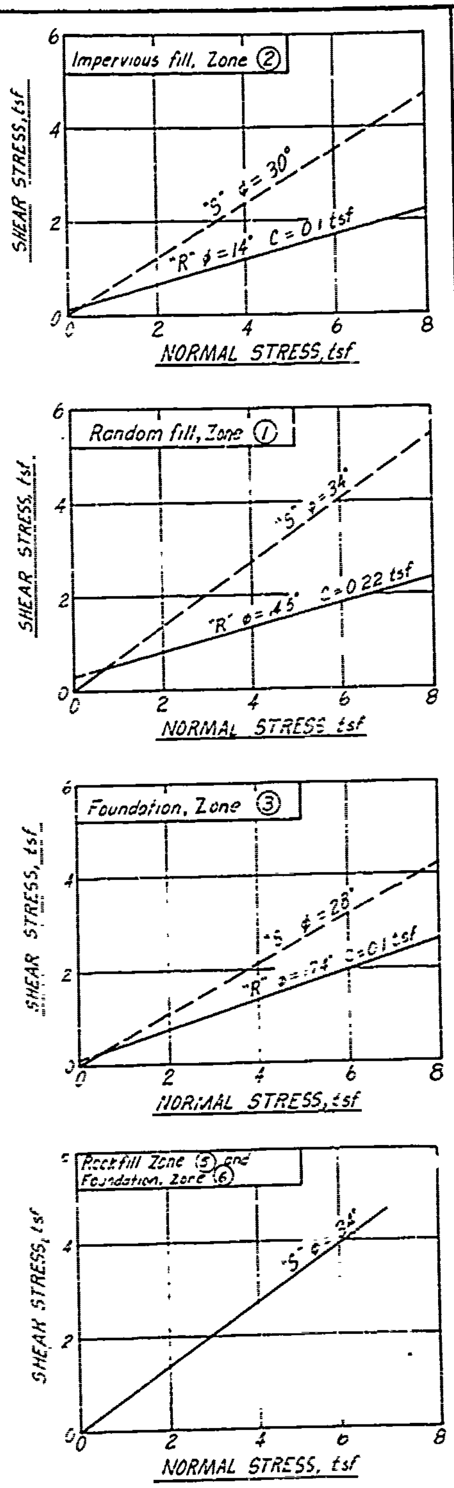
Y FACTORS

...Pool	Critical Pool + earthquake condition
	1.30
	1.40
	1.40

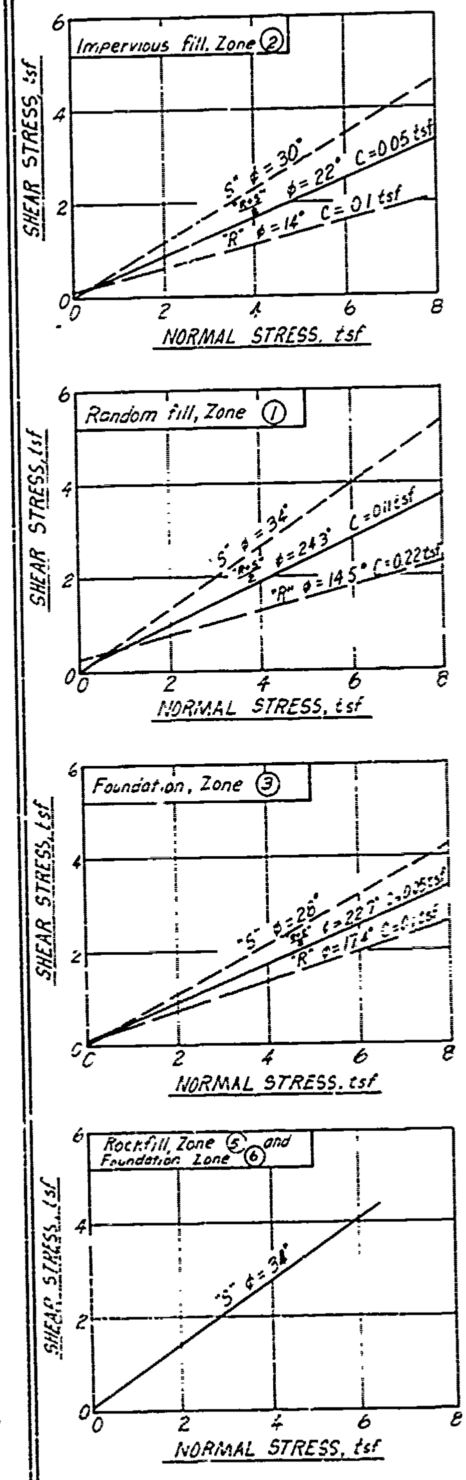
ETY FACTORS

Critical Pool El. 300	Critical Pool + earthquake condition
1.50	1.50
1.75	1.40
1.80	1.50
1.75	1.44
1.65	1.38
1.85	1.55





STRENGTH ENVELOPES FOR SUDDEN DRAWDOWN CONDITION



STRENGTH ENVELOPES FOR PARTIAL POOL CONDITION

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

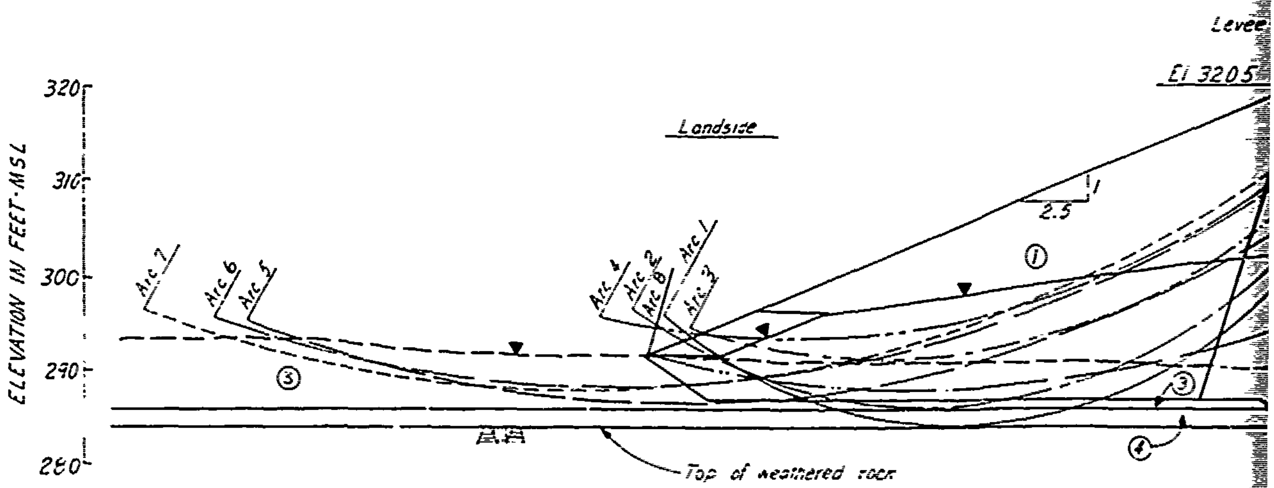
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
SLOPE STABILITY ANALYSIS
RIVERSIDE SLOPE

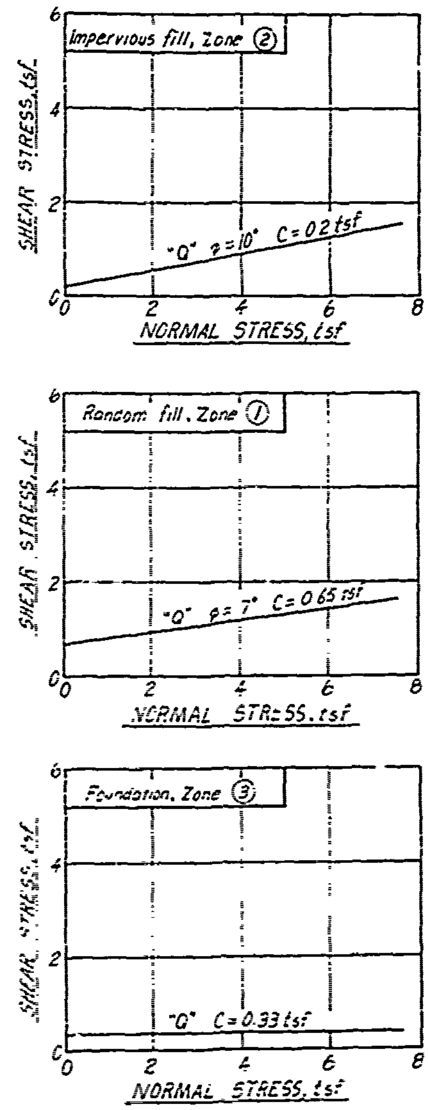
D.M. NO. 13 3 PLATE B-2

Zone	Description	Unit (…
1	Random Clayey Silty Sandy GRAVEL (GW GC)	125
2	Impervious Gravelly Clayey SAND (SC)	120
3	Sandy CLAY CL	115
4	Highly weathered SHALE in form of Clayey Sandy GRAVEL GC	125

MAIN LEVEE – LANDSIDE SAFETY FACTORS

Sliding Surface	Radius (ft)	End of Construction	Earthquake End of Construction	Steady Seepage	Steady Seepage + Earthquake Condition
Arc 1	50	2 50	2 15	1 70	1 40
Arc 2	56	2 17	1 86	1 50	1 30
Arc 3	70	3 31	2 85	1 70	1 40
Arc 4	54	4 00	3 50	1 80	1 55
Arc 5	133			1 84	
Arc 6	137			1 50	
Arc 7	138 5			2 00	
Arc 8	126 5			1 94	

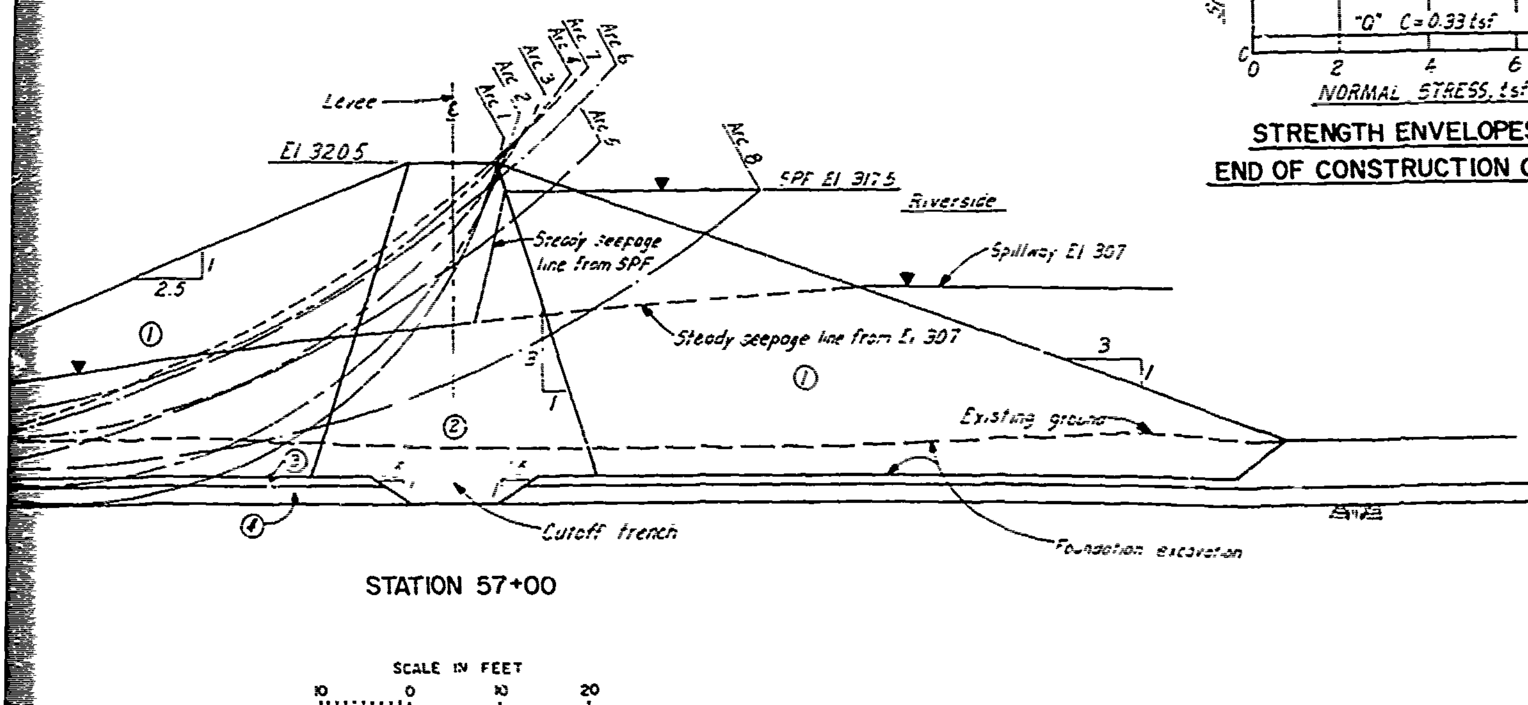




STRENGTH ENVELOPES FOR END OF CONSTRUCTION CONDITION

ADOPTED DESIGN VALUES

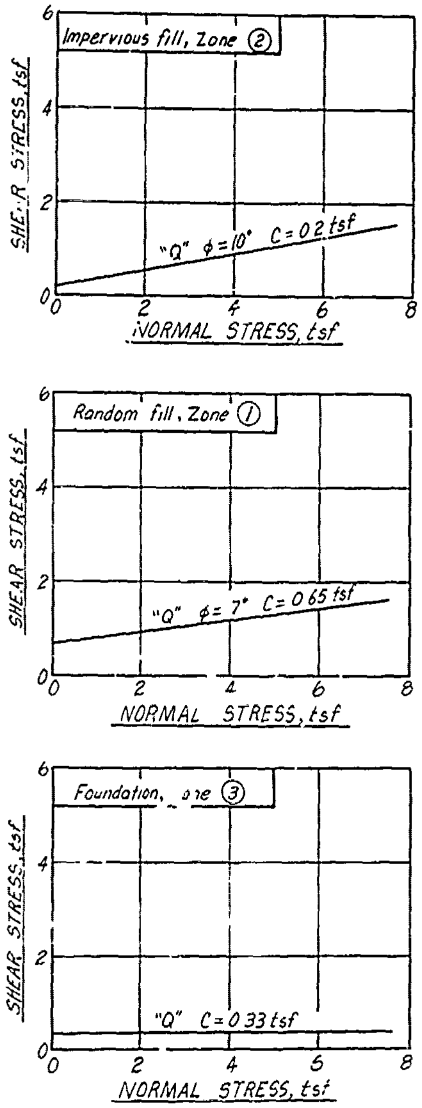
Zone	Description	Unit wt pcf		Q Strength		R Strength		S Strength	(R+S)/2 Strength	
		[illegible]	[illegible]	φ °	C psf	φ °	C psf	φ °	φ °	C psf
1	Random Clayey Silty Sandy GRAVEL (GM-GC)	125	130	7	1300	14.5	440	34	24.3	220
2	Impervious Gravelly clayey SAND (SC)	120	125	10	400	14	200	30	22	100
3	Sandy CLAY (CL)	115	120	0	650	17.4	200	28	22.7	100
4	Highly weathered SHALE in form of Clayey Sandy GRAVEL (GC)	125	130	7	1300	14.5	820	34	24.3	400



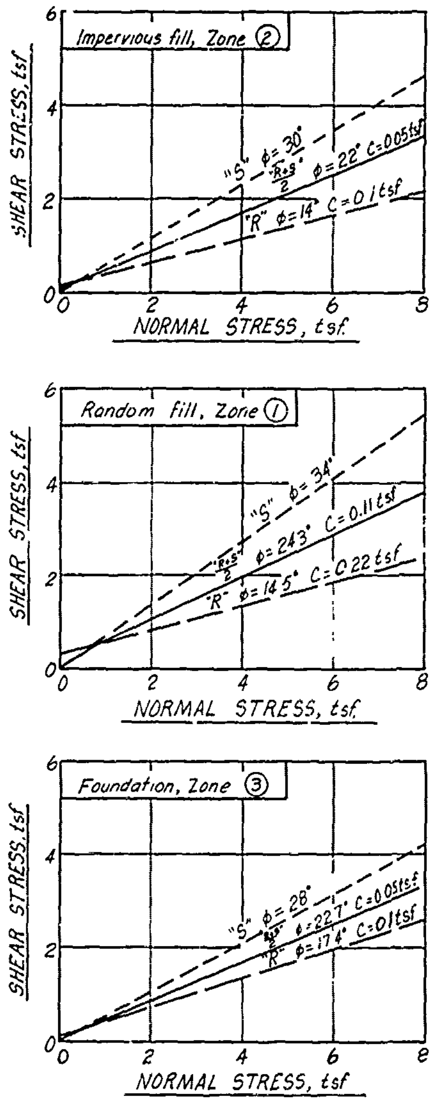
STATION 57+00

VALUES

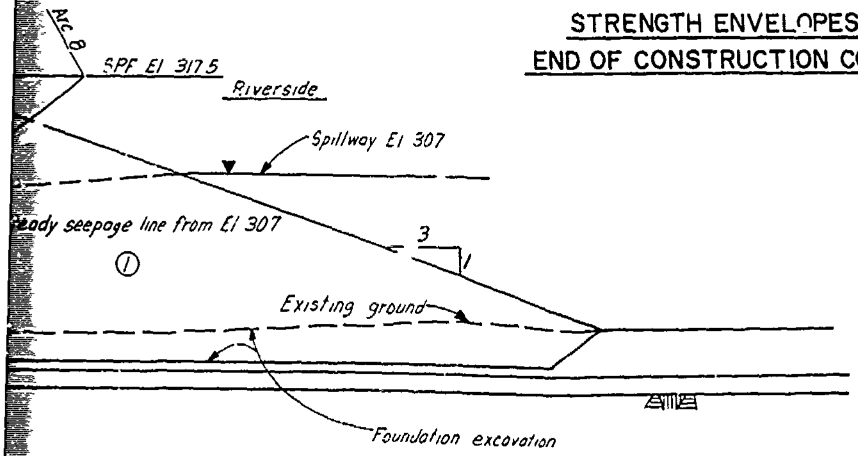
Strength C (psf)	S Strength φ (°)	$\frac{R+S}{2}$ Strength φ (°)	C (psf)
440	34	24 3	220
200	30	22	100
200	28	22 7	100
800	34	24 3	400



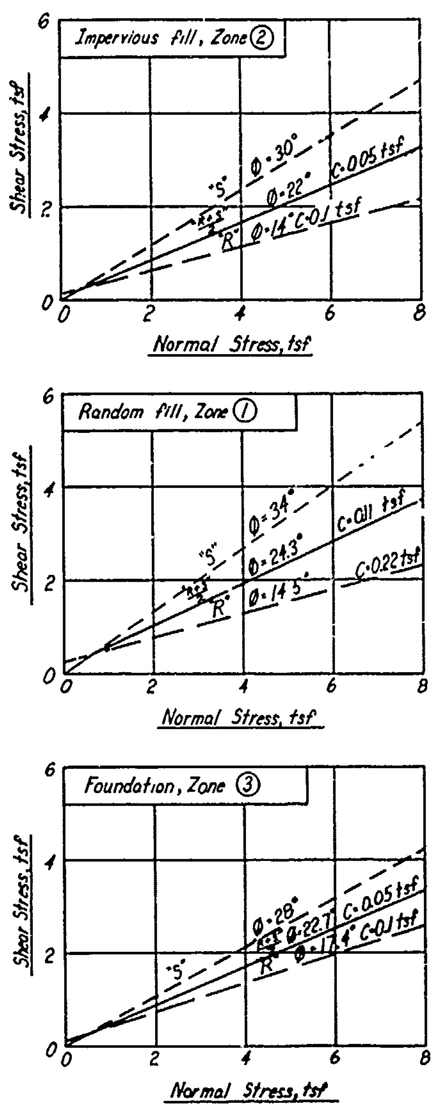
STRENGTH ENVELOPES FOR END OF CONSTRUCTION CONDITION



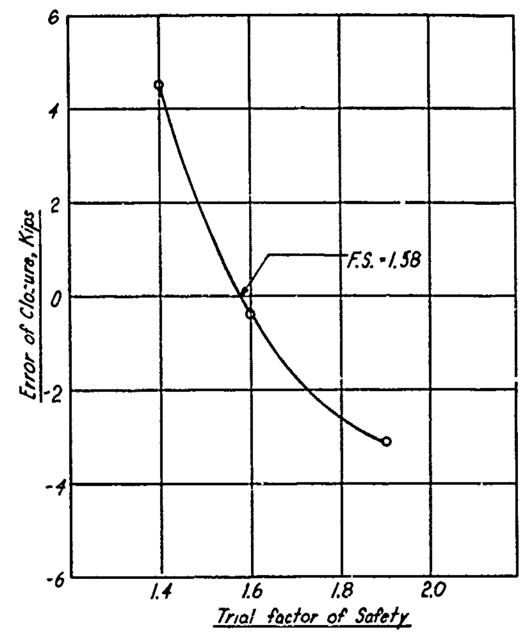
STRENGTH ENVELOPES FOR STEADY SEEPAGE CONDITION



SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.
BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
SLOPE STABILITY ANALYSIS
LANDSIDE SLOPE



COMPOSITE STRENGTH ENVELOPES



TRIAL FACTORY OF SAFETY VERSUS ERROR OF CLOSURE

LEGEND

W_5 = Weight of Slice 5 (Total)

$E_{4\text{-}5}$ = Earth force on boundary of slice 4 & 5

C_{D5} = Developed cohesion force on base of slice 5

N_5 = Normal force at base of slice 5

ϕ_{D5} = Developed angle of friction for soil at base of slice 5

F_{D5} = Resultant of normal & developed friction forces for slice 5

U_{L5} = Water force on left side of slice 5

U_{R5} = Water force on right side of slice 5

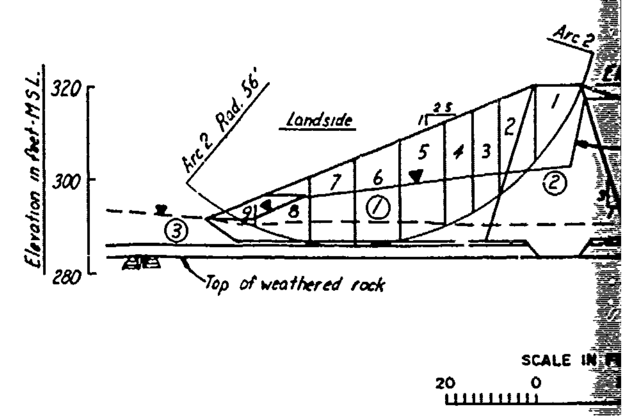
U_{B5} = Water force on base of slice 5

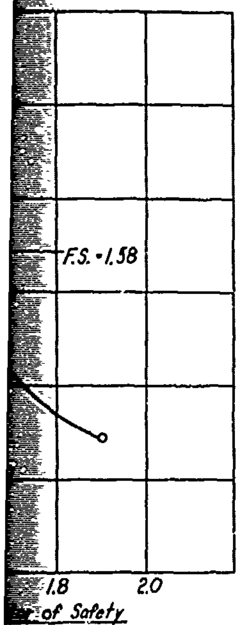
TABLE OF FORCES

Levee Zone or Foundation Layer	Slice	Weight Kips			Base Length of slice ΔL ft	C·ΔL, Kips	U_L Kips	U_R Kips	U_L-U_R Kips	U_B Kips
		Moist	Saturated	Total						
Impervious Fill	1	15 1		15 1	22	2 2	0	0	0	0
	2	12 3	1 9	14 2	8 5	0 9	0 8	0	0 8	1 3
Random Fill	3	10 9	5 1	16	7 5	1 7	2 0	0 8	1 2	3 0
	4	9 8	6 9	16 7	6 5	1 4	3 4	2 0	1 4	3 8
	5	13 1	14 2	27 3	10 5	2 3	4 5	3 4	1 1	7 4
Foundation Zone 3	6	10 1	15 6	25 6	10 0	1 0	4 5	4 5	0	7 5
	7	6 3	13 9	20 2	10 0	1 0	3 1	4 5	-1 4	6 9
Random Fill	8	2 6	11 6	14 2	12 5	2 8	0 8	3 1	-2 3	5 9
	9	0 5	2 0	2 5	9 0	0	0	0 8	-0 8	1 4

ADOPTED DESIGN VALUES

Zone	Description	Unit Weight (pcf)		"R" Strength		"S" Strength	"(R+S)/2" Strength	
		γ_m	γ_s	Φ (°)	C (psf)	Φ (°)	Φ (°)	C (psf)
①	Random- Clayey silty Sandy GRAVEL (GM-GC)	125	130	14 5	440	34	24 3	220
②	Impervious-Gravelly clayey SAND (SC)	120	125	14	200	30	22	100
③	Gray Sandy CLAY (CL)	115	120	17 4	200	28	22 7	100
④	Highly weatn shale in form of clayey sandy GRAVEL (GP-GC) w some cobbles	125	130	14 5	800	34	24 3	400





...Y OF SAFETY
...OF CLOSURE

LEGEND

W_5 = Weight of Slice 5 (Total)

$E_{4\text{-}5}$ = Earth force on boundary of slice 4 & 5

C_{D5} = Developed cohesion force on base of slice 5

N_5 = Normal force at base of slice 5

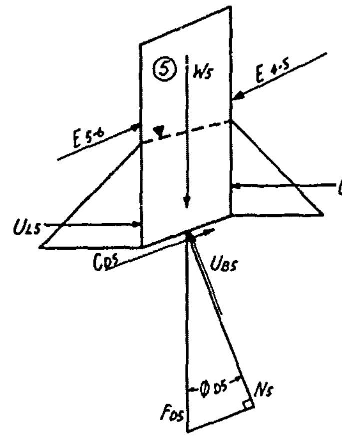
ϕ_{D5} = Developed angle of friction for soil at base of slice 5

F_{D5} = Resultant of normal & developed friction forces for slice 5

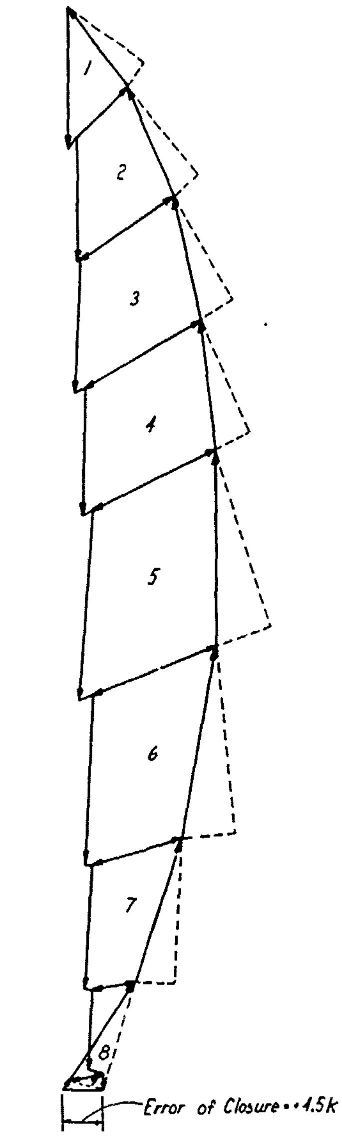
U_{L5} = Water force on left side of slice 5

U_{R5} = Water force on right side of slice 5

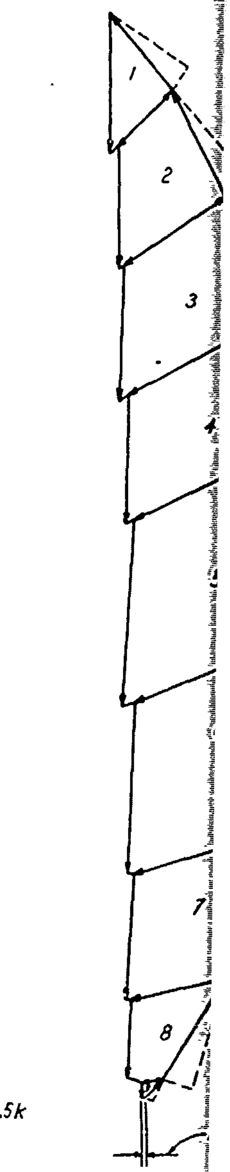
U_{B5} = Water force on base of slice 5



FORCES ACTING ON TYPICAL SLICE



For Trial F.S. = 1.4



For Trial F.S...

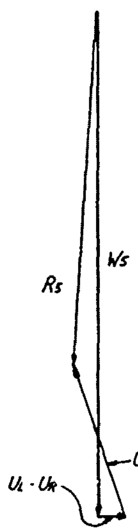
COMPOSITE FORCE...

SCALE IN KI...

10 0

TABLE OF FORCES

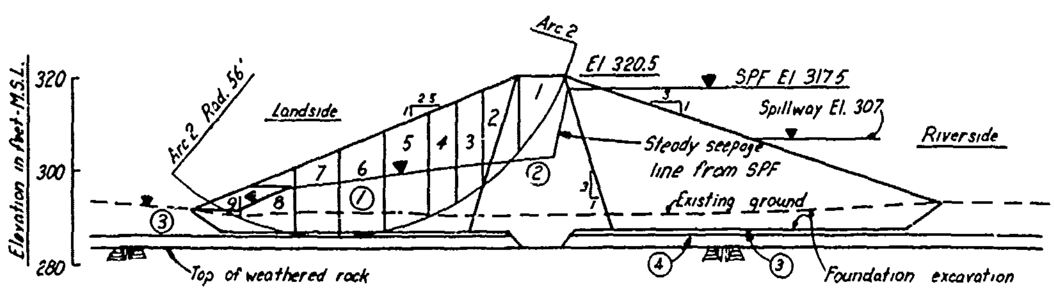
... Total	Base Length of slice ΔL, ft	C·ΔL, Kips	U_L Kips	U_R Kips	U_L-U_R Kips	U_B Kips
15.1	22	2 2	0	0	0	0
14 2	8 5	0 9	0 8	0	0 8	1 3
16.0	7 5	1 7	2 0	0 8	1 2	3 0
16.7	6 5	1 4	3 4	2 0	1 4	3 8
27.3	10 5	2 3	4 5	3 4	1.1	7 4
23 6	10 0	1 0	4 5	4 5	0	7 5
20.2	10 9	1 0	3 1	4 5	-1 4	6 9
14.2	12 5	2 8	0 8	3 1	-2 3	5 9
2.5	9 0	0	0	0 8	0 8	1 4



RESULTANT OF WEIGHT AND WATER FORCES ON SLICES

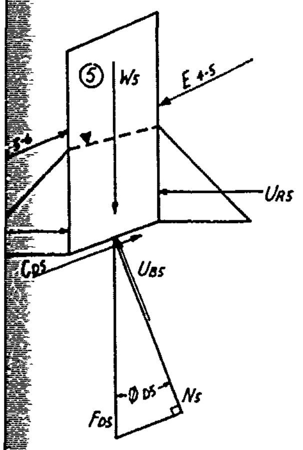
SCALE IN KIPS

5 0 5 10

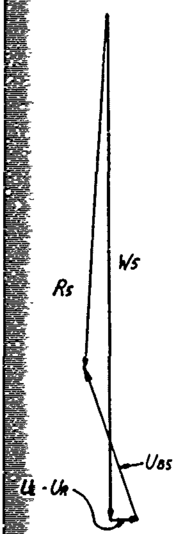


SCALE IN FEET

20 0 20 40

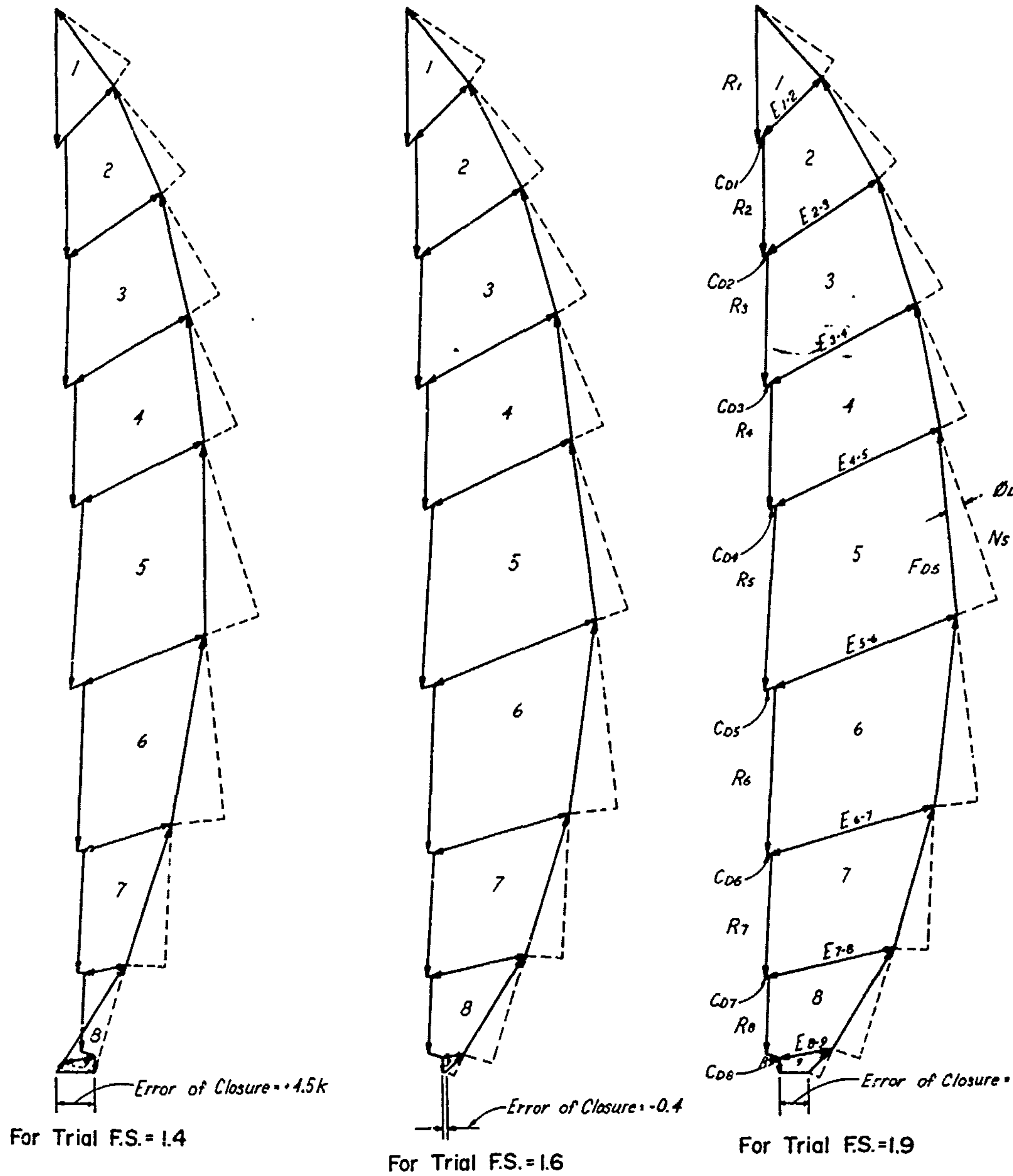


FORCES ACTING ON TYPICAL SLICE



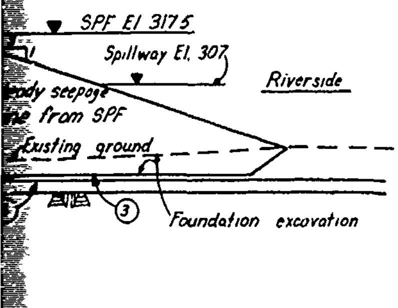
ULTANT OF WEIGHT AND
ER FORCES ON SLICES

SCALE IN KIPS
5 0 5 10



COMPOSITE FORCE POLYGONS

SCALE IN KIPS
10 0 10 20



SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PA.

BLUE MARSH LAKE
BERNVILLE PROTECTIVE WORKS
STABILITY ANALYSIS-LANDSIDE SLOPE
STEADY SEEPAGE-SAMPLE CALCULATION
MODIFIED SWEDISH METHOD

BY .... DATE .... SUBJECT Barnvilla Protective Works D.M. SHEET NO. .... OF .

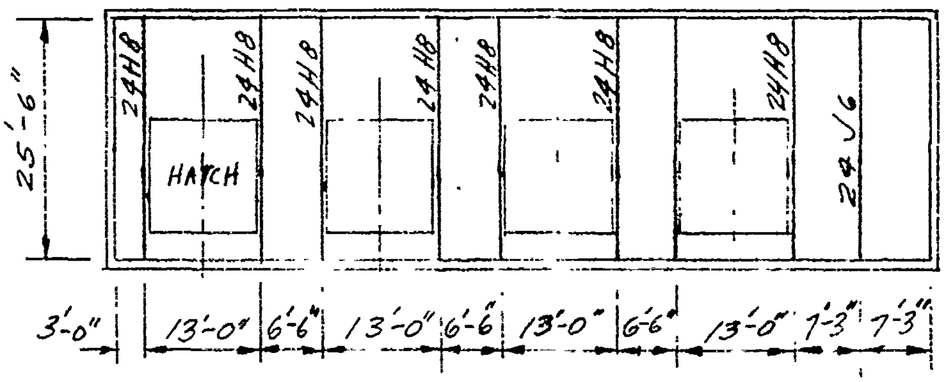
CHKD. BY .... DATE .... JOB NO. ....

Index

BY R.G.B. DATE 11 SEPT 74 SUBJECT BERNVILLE SHEET NO. 1 OF
CHKD. BY DATE PROTECTIVE WORKS D.M. JOB NO.
PUMPING STATION SUPERSTRUCT. 29.1

ROOF BEAMS

SNOW LOAD	25 PSF
5 PLY ROOFING	6 PSF
2" RIGID INSUL.	4 PSF
22 GAGE STEEL DECK	2 PSF
MISCELLANEOUS	8 PSF
TOTAL	45 PSF



$w = 9.75(45) = 439$ LB/FT

USE 24 H 8 REF.- AISC P. 5-297

$w = 10.13(45) = 456$ LB/FT

USE 24H8

$w = 7.25(45) = 326$ LB/FT

USE 24 J 6

BY R.G.B. DATE 17 JUNE 74 SUBJECT BERNVILLE SHEET NO. 1 OF

CKD. BY WQG DATE 26 JULY 74 PROTECTIVE WORKS D.M. JOB NO.

PUMP STATION pg. 2

DESIGN CRITERIA

REFERENCES:

1) EM 1110-2-3101
2) EM 1110-2-2000
3) EM 1110-2-2502
4) EM 1110-2-2101
5) EM 1110-2-2103
6) ETL 1110-2-184

SOIL DATA:

$\gamma_{nat} = 125$ PCF

$\gamma_{sat} = 135$ PCF

$\gamma_{sub} = 72.5$ PCF

$\phi = 22°$

$K_r = 0.6$

ROCK FOUNDATION DATA:

ALLOW. BRG = 20 KSF

$S = 5$ KSF

$\phi = 32°$

$\phi' = 45°$ (BETWEEN CONCRETE & ROCK)

BY R.G.B. DATE 17 JUNE 74 SUBJECT BERLIVILLE SHEET NO. 2 OF

CHKD. BY WJG DATE 26 JULY 74 PROTECTIVE WORKS D.M. JOB NO.

PUMP STATION - STABILITY pg. 3

LOAD CONDITIONS

CASE I - CONSTRUCTION CONDITION - SUBSTRUCTURE W/O EQUIPMENT; BACKFILL IN PLACE; DEAD LOADS; ROLLER LOAD (300 PSF)

CASE II - FLOATATION CONDITION - DEAD LOADS; POND AND SUBMERGENCE LINE AT EL. 300; GATES CLOSED AND NO WATER IN SUMPS

CASE III - OPERATING CONDITION - DEAD LOADS; ALL PUMPS OPERATING; POND AND SUBMERGENCE LINE AT EL. 300

BY R.G.B. DATE 10 JULY 74 SUBJECT BER[illegible]

CHKD. BY WJJ DATE 26 JULY 74 PROTECTIVE WORKS D.M.

PUMP STATION - STABILITY

SHEET NO. 3 OF

JOB NO.

pg. A

CASE I

ITEM	DESCRIPTION	V	H_y	H_x	X	Y	Z	M_y	M_x
	CONCRETE								
C_1	1.5(24)(91)(.150)	491.4			45.5	0.75		22,359	369
C_2	41.5(2.5)(91.0)(.150)	1416.2			45.5	20.75		64,437	29,386
C_{13}	2.5(2)(91)(.150)	68.3			45.5	-1.0		3105	-68
C_3	29.0(18.0)(1)(.150)(4)	313.2			39.75	14.5		12,450	4541
C_4	1(1)(18.0)(.150)(4)	10.8			39.75	34.0		429	367
C_5	23.0(1.0)(18)(4)(.150)	248.4			39.75	28.0		9874	6955
	-10(12)(1)(4)(.150)	-72.0			39.75	26.0		-2385	-2016
C_6	40(24)(1.5)(.150)(5)	1080.0			39.75	21.5		42,930	23,220
C_7	-24(6)(.5)(1.5)(.150)(4)	-64.8			30.0	39.5		-1944	-2560
C_8	1.5(38.5)(24)(.150)	207.9			90.25	20.75		18,763	4314
C_9	1(10)(38.5)(.150)	57.8			84.5	20.75		4880	1199
C_{10}	1.5(24)(11.5)(.150)	62.1			85.25	42.0		5294	2604
C_{11}	1.3(2.5)(.5)(18)(4)(.150)	17.6			39.75	27.1		698	477
C_{12}	2.5(13)(.6)(4)(.150)	351.0			39.75	2.75		13,952	965
	SUB-TOTAL 1	4187.9						190,842	[illegible]
	LAT. EARTH								
P_1	$(26)^2(.125)(0.6)(\frac{1}{2})(91)$		2306.8				8.67		20,000
P_2	0.3(26)(0.6)(91)		425.9				13.0		5536
	SUB-TOTAL 2		2732.7						25,536
	VERT. EARTH								
	23.5(.125)(2)(91)	534.6			45.5	-1.0		24,325	-535
	TOTAL	4722.5	2732.7					219,167	94,634

$$\bar{X} = \frac{\Sigma M_y}{\Sigma V} = \frac{219167}{4722.5} = 46.41'$$

$$\bar{Y} = \frac{\Sigma M_x}{\Sigma V} = \frac{94634}{4722.5} = 20.04'$$

BY R.G.B. DATE 23 JULY 74 SUBJECT BERNVILLE PROTECTIVE WORKS D.M. PUMP STATION - STABILITY
CHKD. BY G.H. DATE 9/5/74
SHEET NO. 3A OF
JOB NO.
pg. 5

CASE I (CONT)

SHEAR - FRICTION SAFETY FACTOR

ROCK

$$S_{S-f} = \frac{\Sigma V \tan\phi + SA + 2SD}{\Sigma H}$$

$$= \frac{4722.5(.625) + 5(5958.5) + 2(5)(2.5)(91.0)}{2732.7}$$

$$S_{S-f} = 9.2 > 4 \quad O.K.$$

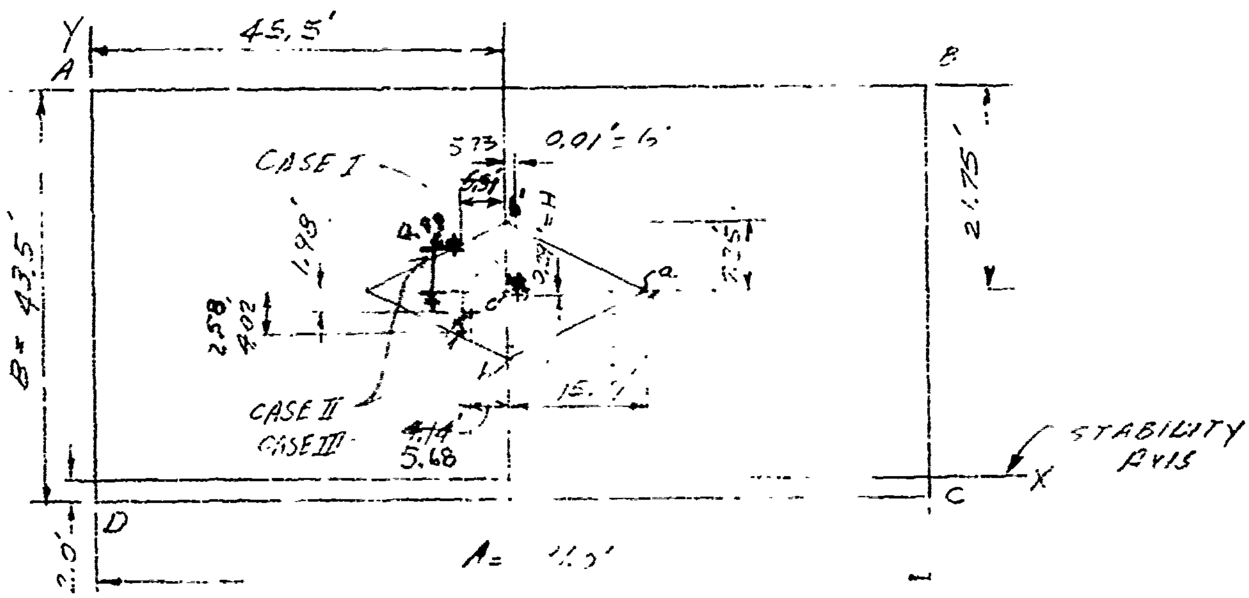
CONCRETE - ROCK

$$S_{S-f} = \frac{\Sigma V \tan\phi' + 2SD}{\Sigma H}$$

$$= \frac{4722.5(1) + 2(5)(2.5)(91.0)}{2732.7}$$

$$S_{S-f} = 2.6 > 1.5 \quad O.K.$$

BASE PRESSURE



BY R.G.B. DATE 7 AUG 74 SUBJECT BURNVILLE SHEET NO. 38 OF
CHKD. BY G.H. DATE 9/5/74 PROTECTIVE WORKS D.M. JOB NO.
PUMP STATION - STABILITY pg. 6

CASE I (CONT)

BASE PRESSURE (CONT)

REF. - "FOUNDATION PRESSURES UNDER RECTANGULAR BASES ECCENTRICALLY LOADED" R.P.V. MARQUARDSEN

$$V_a = V\frac{6G}{A} = \frac{4722.5(6)(0.91)}{91.0} = 283.4^K.$$

$$V_b' = V\frac{6H}{B} = \frac{4722.5(6)(0.29)}{43.5} = 188.9^K.$$

$$V_c = V\left[1 - \frac{6(AH+BG)}{AB}\right] = 4722.5\left\{1 - \frac{6[(91.0)(0.29) + 43.5(0.91)]}{91.0(43.5)}\right\}$$

$$V_c = 4250.3^K.$$

$$P_{A_D} = \frac{V_c}{AB} = \frac{4250.3}{3958.5} = 1.07 \text{ KSF.}$$

$$P_{\&C} = \frac{V_c}{AB} + \frac{2V_a}{AB} = 1.07 + \overset{0.14}{\frac{2(283.4)}{3958.5}} = 1.21 \text{ KSF.}$$

$$P_{\&B} = \frac{V_c}{AB} + \frac{2V_a}{AB} + \frac{2V_b'}{AB} = 1.07 + 0.14 + \overset{0.10}{\frac{2(188.9)}{3958.5}} = 1.31 \text{ KSF.}$$

$$P_{\&A} = \frac{V_c}{AB} + \frac{2V_b'}{AB} = 1.07 + 0.10 = 1.17 \text{ KSF.}$$

BY R.G.B. DATE [illegible] 74 SUBJECT BE[illegible]
PROJE[illegible] WORKS O.M.
PUMP STATION - STABILITY
CHKD. BY G.H. DATE 9/5/74
SHEET NO. 4 OF
JOB NO.

CASE II

ITEM	DESCRIPTION	V	H_y	H_x	X	Y	Z	M_y	M_x
	SUB-TOTAL 1 (CASE I)	4187.9						194,842	69,633
P_1 ΔP_1	LAT. EARTH CASE I $-(23.5)^2(.0525)(0.6)(\frac{1}{2})(91)$		2306.8 -791.5				7.83		20,000 -6198
	SUB-TOTAL 1		1515.3						13,802
WALLS ROOF	SUPERSTRUCTURE 14(27+27+91+91)(.04+.038) 25(89)(.007)	257.7 15.6			45.5 45.5	13.5 13.5		11,726 709	3479 211
	SUB-TOTAL 2	273.3						12,435	3690
W1 W2	VERT. WATER 21(.0325)(1[illegible])(18)(4) 5.15(21)(.5)(1.5)(4)(.0625)	1228.5 20.7			39.75 30.0	35.0 39.75		48,833 620	42,998 823
	SUB-TOTAL 3	1249.2						49,453	43,821
U1	UPLIFT 43.5 -23.5(.0625)(47.5)(91)	5014 -5546.7			45.5	19.75 20.75		-264,537 -252,376	-114,826 -115,094
	PUMPS 60(4) 10(1)	240 10			39.75 84.5	9.0 9.0		9540 845	2160 90
	SUB-TOTAL 4	250						10,385	2250

BY R.G.B. DATE 6AUG74 SUBJECT BERNVILLE PROTECTIVE WORKS D.M. PUMP STATION - STABILITY SHEET NO. 4A OF

CHKD. BY G.H. DATE 9/5/74 JOB NO.

pg 8

CASE II (CONT)

ITEM	DESCRIPTION	V	H_y	H_x	X	Y	Z	M_y	M_x
	VERT. EARTH (CASE I) 21.1(.010)(2)(91)	534.6 38.2			45.5	-1.0		24,325 1739	-535 -38
	SUB-TOTAL S	572.8						26,064	-573
	TOTAL	986.5 719.2	1515.3					40803 28,642	17,529 17,797

$$\bar{X} = \frac{\Sigma M_y}{\Sigma V} = \frac{\overset{28642}{40{,}803}}{\underset{719.2}{986.5}} = \overset{39.82}{41.36'}$$

$$\bar{Y} = \frac{\Sigma M_x}{\Sigma V} = \frac{\overset{17797}{17529}}{\underset{719.2}{986.5}} = \overset{24.74}{17.77'}$$

SHEAR-FRICTION SAFETY FACTOR

ROCK

$$S_{s-f} = \frac{\Sigma V \tan\phi + SA + z\,SD}{\Sigma H} = \frac{\overset{719.2}{986.5}(.625) + 5(3958.5) + 2(5)(2.5)(91.0)}{1515.3}$$

$$S_{s-f} = \overset{14.8}{15.0} > 4 \quad \text{O.K.}$$ ok.

CONCRETE-ROCK

$$S_{s-f} = \frac{\Sigma V \tan\phi' + z\,SD}{\Sigma H} = \frac{\overset{719.2}{986.5}(1) + 2(5)(2.5)(91.0)}{1515.3}$$

$$S_{s-f} = \overset{1.98}{2.2} > 1.5 \quad \text{O.K.}$$

BY R.G.B. DATE 8 AUG 74 SUBJECT BELLVILLE PROTECTIVE WORKS PUMP STATION - STABILITY SHEET NO. 48 OF

CHKD. BY G.H. DATE 9/5/74 JOB NO. 29.9

CASE II (CONT)

BASE PRESSURE

719.6 5.0

$V_a = V \frac{6G}{A} = \frac{986.5(6)(4.14)}{91} = 269.3^K$

719.2 4.99 495.0

$V_b = V \frac{6H}{B} = \frac{986.5(6)(1.98)}{43.5} = 269.*^K$

719.2 4.99 5.18

$V_c = V\left[1 - \frac{6(AH+BG)}{AB}\right] = 986.5\left\{1 - \frac{6[91(1.98)+43.5(4.14)]}{3958.5}\right\}$

$V_c = 447.8^K$ 27.37 .01

77.87 0.15

$P_D = \frac{V_c}{AB} + \frac{2V_a}{AB} = \frac{447.8}{3958.5} + \frac{2(269.3)}{3958.5} = 0.25\ KSF$

0.01

$P_C = \frac{V_c}{AB} = 0.11\ KSF$

.01 0.26

$P_B = \frac{V_c}{AB} + \frac{2V_b}{AB} = 0.11 + 0.14 = 0.25\ KSF$

.01 0.25 .40

$P_A = \frac{V_c}{AB} + \frac{2V_b}{AB} + \frac{2V_a}{AB} = 0.11 + 0.14 + 0.14 = 0.39 KSF$

FOUNDATION PRESSURE

0.40 1.47 1.87

$P_D = 0.39 + 23.5(.0625) = 1.86\ KSF$

Note That this point is out side of the kern

∴ The ... need ...

We neglected This discrepancy

BY R.G.B. DATE 10 JULY 7- SUBJECT BERNVILLE SHEET NO. 5 OF
CHKD. BY G.H. DATE 9/5/74 PROTECTIVE WORKS D.M. JOB NO.
PUMP STATION - STABILITY pg. 1C

CASE III

ITEM	DESCRIPTION	V	H_y	H_x	X	Y	Z	M_y	M_x
	SUB-TOTAL 1 (CASE I)	4187.9						199,942	69633
P_1 ΔP_1	LAT. EARTH CASE I $-(23.5)^2(.0525)(0.6)(\frac{1}{2})(91)$		2306.8 -791.5				7.83		20,000 -6198
	SUB-TOTAL 1		1515.3						13,[illegible]
	SUB-TOTAL 2 (CASE II)	273.3						12,435	3[illegible]0
	PUMP. THRUST 800(.0625)(8.4)/32.2		13.0				21.0		273
W1 W2	VERT. WATER 21(.0625)([illegible]8)(4) -1(21)(18)(4 .25) ak. -2.5(13)(18)(4)(.0625) 5.25(21)(.5)(1.5)(4)(.0625)	 3780 3770 -94.5 -146.2 20.6			 39.75 39.75 39.75 30.0	 21.5 28.0 2.75 39.75		150,255 149,8[illegible] -3755 -58[illegible] 618	81,270 81,000 -2645 -402 [illegible]
	SUB-TOTAL 2	3549.9 3559.9						140,843 141,387	78,772 79,042
	UPLIFT (CASE II)	5814 -5546.7						264537 -252,376	114826 -115,[illegible]
	VERT. EARTH SUB-TOTAL 5 (CASE II)	572.8						26,064	-573
	PUMPS SUB-TOTAL 4 (CASE II)	250						10,385	2250

CASE III (CONT)

ITEM	DESCRIPTION	V	Hy	Hx	x	Y	Z	My	Mx
	PUMP WATER COLUMN $0.0625(26)(5.5)^2\pi(\frac{1}{4})(4)$	154.4			39.75	9.0		6139	1390
	TOTAL	3441.6 3184.3	1528.3					138,332 126,635	54,143 54,681

$$\bar{X} = \frac{\Sigma M_y}{\Sigma V} = \frac{138,332}{3441.6} = 40.19' \quad (126\,635 / 3184.3 = 39.77)$$

$$\bar{Y} = \frac{\Sigma M_x}{\Sigma V} = \frac{54,143}{3441.6} = 15.73' \quad (54\,681 / 3184.3 = 17.17)$$

SHEAR-FRICTION SAFETY FACTOR

ROCK

$$S_{s-f} = \frac{\Sigma V \tan\phi + SA + 2SD}{\Sigma H} = \frac{3441.6(.625) + 5(3958.5) + 2(5)(2.5)(91)}{1528.3}$$

(3184.3 written above 3441.6)

$$S_{s-f} = 15.8 > 4 \quad O.K.$$ (15.7 written above)

CONCRETE - ROCK

$$S_{s-f} = \frac{\Sigma V \tan\phi' + 2SD}{\Sigma H} = \frac{3441.6(1) + 2(5)(2.5)(91.0)}{1528.3}$$

(3184.3 written above 3441.6)

$$S_{s-f} = 3.7 > 1.5 \quad O.K.$$ (3.6 written above)

BY R.G.B. DATE 8AUG74 SUBJECT BERNVILLE SHEET NO. 7 OF
CHKD. BY G.H. DATE 9/6/74 PROTECTIVE WORKS D.M. JOB NO.
PUMP STATION - STABILITY pg. 12

CASE III (CONT)

BASE PRESSURE

$$V_a = V\frac{6G}{A} = \frac{\overset{3184.3}{3441.6}(6)(\overset{5.73}{5.31})}{91} = \overset{1203.0}{1204.9}^k$$

$$V_b' = V\frac{6H}{B} = \frac{\overset{3184.3}{3441.6}(6)(\overset{2.58}{4.02})}{43.5} = \overset{1133.2}{1908.3}K$$

$$V_c = V\left[1 - \frac{6(AH+BG)}{AB}\right] = \overset{3184.3}{3441.6}\left\{1 - \frac{6[91(\overset{2.58}{4.02})+43.5(\overset{5.73}{5.31})]}{3958.5}\right\}$$

$$V_c = 328.4^k \quad 848.1$$

$$P_A = \frac{V_c}{AB} + \frac{2V_a}{AB} = \frac{\overset{848.1}{328.4}}{3958.5} + \frac{2(\overset{1203}{1204.9})}{3958.5} = \overset{0.82}{0.67}\ KSF$$

(.21, 0.08, 0.61 written above terms)

$$P_B = \frac{V_c}{AB} = \overset{.21}{0.08}\ KSF$$

$$P_C = \frac{V_c}{AB} + \frac{2V_b}{AB} = \overset{.21}{0.08} + \frac{2(\overset{1133.2}{1908.3})}{3958.5} = \overset{.78}{1.04}\ KSF$$

(.57, 0.96 written above term)

$$P_D = \frac{V_c}{AB} + \frac{2V_b}{AB} + \frac{2V_a}{AB} = \overset{0.21}{0.08} + \overset{0.78}{0.96} + \overset{0.82}{0.61} = \overset{1.81}{1.65}\ KSF$$

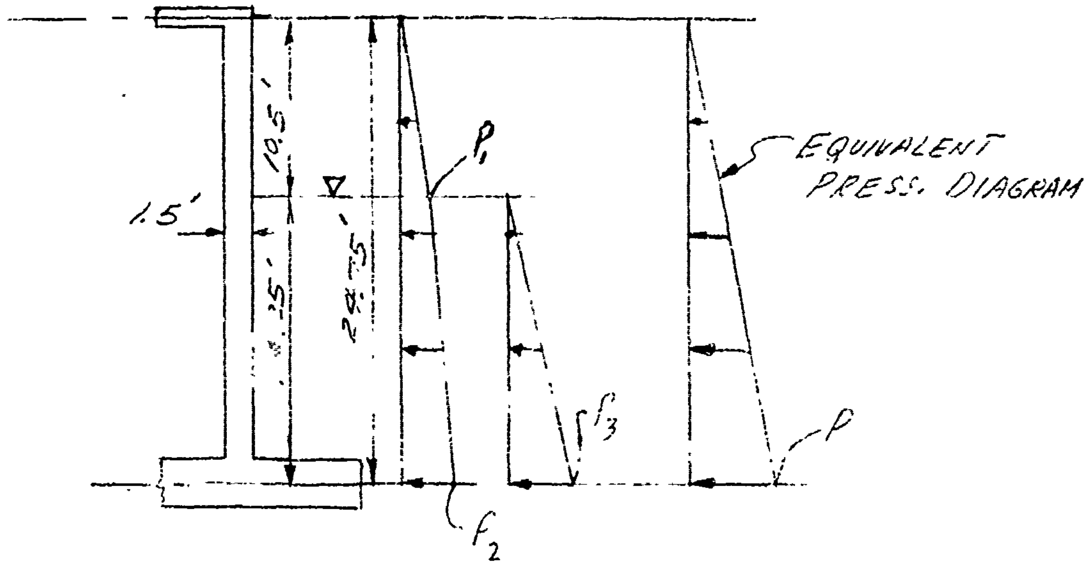
FOUNDATION PRESSURE

$$P_D = \overset{1.81}{1.65} + 1.47 = \overset{3.28}{3.12}\ KSF$$

BY R.G.B. DATE 20 JUNE 74	SUBJECT BERNVILLE	SHEET NO. 10 OF
CHKD. BY WJG DATE 26 JULY 74	PROTECTIVE WORKS D.M.	JOB NO.
	PUMP STATION - REINF.	pg. 13

WALL 1

CASE II LOADING CONDITION



$P_1 = 10.5(.125)(.6) = 0.79$ KSF

$P_2 = 0.79 + 14.25(.0725)(.6) = 1.41$

$P_3 = 14.25(.0625) = 0.89$ KSF

$$P = \Big[\overset{4.15}{0.79(10.5)(\tfrac{1}{2})} + \overset{11.26}{0.79(14.25)} + \overset{4.42}{(1.41-0.79)(14.25)(\tfrac{1}{2})} + \overset{6.34}{0.89(14.25)(\tfrac{1}{2})}\Big]\frac{2}{24.75}$$

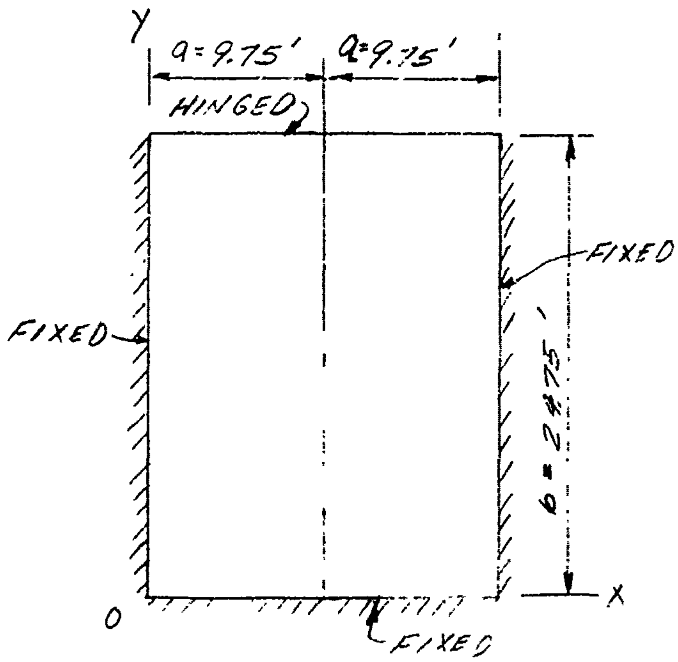
$P = 2.11$ KSF

BY R.G.B. DATE 21 JUNE 74 SUBJECT BEEYVILLE SHEET NO 11 OF

CHKD. BY WJG DATE 26 JULY 74 PROTECTIVE WORKS D.M. JOB NO.

PUMP STATION - REINF. pg. 19

WALL 1 (CONT)



REF. - ENGINEERING MONOGRAPH NO. 27, U.S. DEPT. OF THE INTERIOR BUREAU OF RECLAM.

ASSUMED EDGE CONDITIONS

$$\frac{a}{b} = \frac{9.75}{24.75} = 0.394$$

FIG. 13

$$M_x = +0.0207\,(2.11)\,(24.75)^2 = +26.75'K$$

$$M_x = -0.0098\,(2.11)\,(24.75)^2 = -12.67'K$$

$$M_y = +0.0200\,(2.11)\,(24.75)^2 = +25.85'K$$

$$M_y\ -0.0063\,(2.11)\,(24.75)^2 = -8.14'K$$

$$R_x = +0.2120\,(2.11)(24.75) = +11.07\ K$$

$$R_y = +0.0502\,(2.11)(24.75) = +2.62\ K$$

BY R.G.B. DATE 21 JUNE 74 SUBJECT BERNVILLE
CHKD. BY WJG DATE 26 JULY 74 PROTECTIVE WORKS D.M.
PUMP STATION - REINF.

SHEET NO. 12 OF
JOB NO.
pg. 15

WALL 1 (CONT)

$f'_c = 3000$ PSI $\quad f_c = 0.35 \; f'_c = 1050$ PSI $\quad f_s = 29\,000$ PSI

$d = 13.5$ in. $\quad d' = 4.5$ in.

$K = 152 \quad F = 0.182$

NEGLECT THRUST

$KF = 152(0.182) = 27.66$

$$A_s = \frac{M}{ad} = \frac{26.75}{1.44(13.5)} = 1.38 \text{ in}^2$$

USE #7 @ 5 HORIZ. EARTH SIDE

$$V_d = 11.07 - \frac{(24.75 - 9.9)}{24.75} \overset{1.42}{2.11} \left(\frac{13.5}{12}\right) \qquad \frac{Y}{b} = .4$$

$V_d = 9.65$ K $\qquad Y = 24.75(.4) = 9.9'$

$$v_d = \frac{V_d}{bd} = \frac{9650}{12(13.5)} = 60 \text{ PSI} = 60 \text{ PSI O.K.}$$

$L_d = 18$ in.

HOOK REQ'D

$f_h = \xi \sqrt{f'_c} = 360\sqrt{3000} = 19{,}718$

$L_e = 0.04 A_b f_h / \sqrt{f'_c} = 0.04(0.60)(19{,}718)/\sqrt{3000} = 8$ in.

USE 10 in + STD HOOK

$$A_s = \frac{M}{ad} = \frac{12.67}{1.44(13.5)} = 0.65 \text{ in}^2$$

USE #8 @ 12 HORIZ SUMP SIDE

$$A_s = \frac{M}{ad} = \frac{25.85}{1.44(13.5)} = 1.33 \text{ in}^2$$

USE #8 @ 6 VERT. EARTH SIDE

$$A_s = \frac{M}{ad} = \frac{8.14}{1.44(13.5)} = 0.42 \text{ in}^2$$

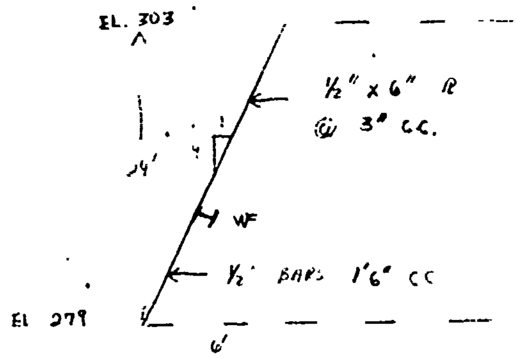
USE #6 @ 12 VERT SUMP SIDE

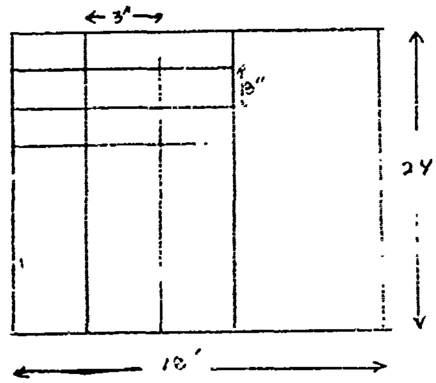
BY W.J.G. DATE 23 JULY 74 SUBJECT BERNVILLE SHEET NO. 1 OF

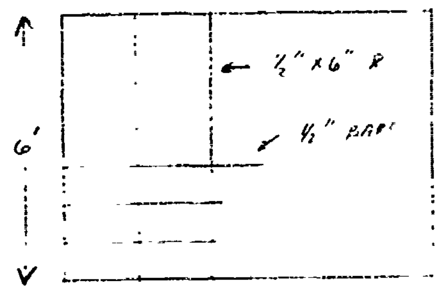
CHKD. BY R.G.B. DATE 25 JULY 74 PROTECTIVE WORKS D.M JOB NO.

PUMP STATION - TRASH RACK pg. 16

SEE DM ON SANDUSKY RIVER AT FREMONT, OHIO BUFFALO, 1966. PLATE 10





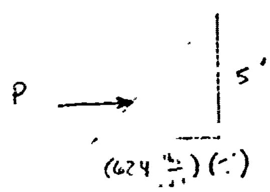


<u>OBJECTIVE</u> : TO DESIGN A TRASH RA[illegible] [illegible]

THAT WILL BE ABLE TO WITHSTAND A 5' DIFFERENTIAL

HEAD WHICH COULD BE BROUGHT ABOUT BY [illegible]OSING.

WATER PRESSURE



Pressure = $\frac{1}{2}(62.4)(5)(5)$ = 780 #/FT

EACH BAR IS RESPONSIBLE FOR 1/4 (.25') OF AREA -

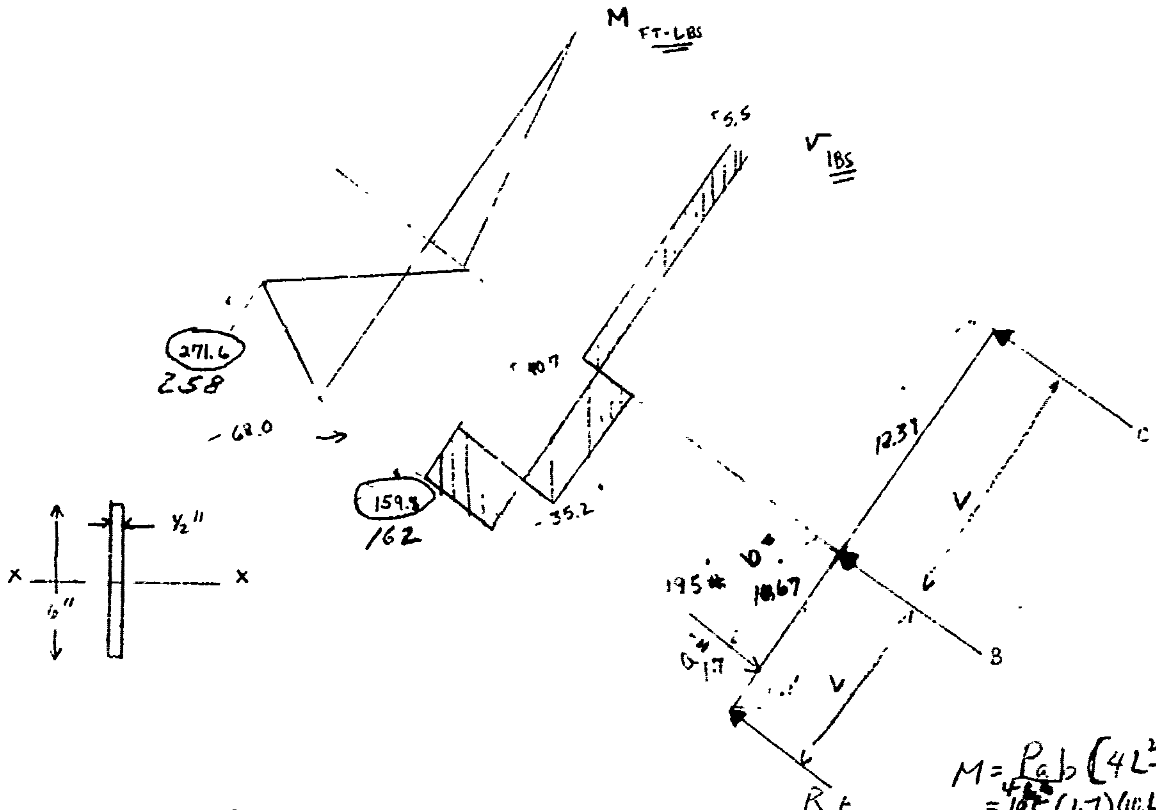
THAT IS, (.25)(780) = 195 #

THIS FORCE WILL ACT AT THE CENTROID OF

THE PRESSURE TRIANGLE - 1.67' FROM THE [illegible]

BY ___ DATE 23 JULY 74 SUBJECT BERNVILLE
CHKD. BY R.G.B. DATE 25 JULY 74 PROTECTIVE WORKS D.M.
PUMP STATION - TRASH RACK

SHEET NO. 2 OF
JOB NO.
pg. 17



$M = \frac{P a b}{4L^3}\left[4L^2 - a(L+a)\right]$

$= \frac{195(1.7)(10.67)}{4(12.37)^3}\left[4(12.37)^2 - 1.7(12.37+1.7)\right]$

$M = 258$ FT-LB

$R_A = \frac{P b}{4L^3}\left[4L^2 - a(L+a)\right]$

$= 161.7$ LB

$\sigma_{ACT} = \frac{P}{A} + \frac{My}{I}$

$\sigma_{ACT} = \frac{159.8 \#}{(6)(1/2)\, in^2} + \frac{(271.6 \text{ FT-LB})(.25)(144\ in^2/ft^2)}{(.0833)(.5)(6)^3\ in^4}$ (258)

$\sigma_{ACT} = 53.2$ psi $+ 1086$ psi (1072)

$\sigma_{ACT} = 1.14$ KSI (1.032)

$** \quad \sigma_{CRE} = \frac{1.13\, \pi\, E}{\sqrt{2(1+\mu)}} \frac{t^2}{l d} \quad *$

* REFERENCE - STEEL STRUCTURES
BY MCGUIRE
PRENTICE HALL 1968
PAGE 711

$\sigma_{CRE} = \frac{(1.13)(3.14)(30 \times 10^3)\ ks.\ (.5)^2\ in^2}{\sqrt{2(1.3)}\ (297\ in)(6\ in)}$ (1.35; 1.3; 148)

$\sigma_{CRE} = 9.33$ KSI (22)

$9.33 > 1.14$ (22)

O.K. ** CRITICAL ELASTIC STRESS

BY: R.G.B. DATE: 2 MAY 74 SUBJECT: BEKNVILLE SHEET NO. 1 OF
CHKD. BY: G.H. DATE: 6/5/74 PROTECTIVE WORKS D.M. JOB NO.
M.18

PIPE ARCH CULVERT

SPAN 16'-5", RISE 9'-11"
CORRUGATION 6"x2"
HEIGHT OF COVER = 15'
LIVE LOAD = H20
WEIGHT OF SOIL = 130 PCF

DESIGN PRESSURE: REF. - HANDBOOK OF STEEL DRAINAGE & HIGHWAY CONSTRUCTION PRODUCTS, 1971

$P_v = K(DL + LL)$

$DL = HW = 15(130) = 1950$ PSF

LL < 100 PSF NEGLECT K = 1.0 WHEN HEIGHT [illegible] < SPAN

$P_v = 1.0(1950) = 1950$ PSF

RING COMPRESSION:

$C = P_v \frac{S}{2} = 1950 \left(\frac{16.42}{2}\right) = 16{,}010$ LB/FT

ALLOWABLE WALL STRESS:

$f_c = \frac{f_b}{2} = \frac{33000}{2} = 16{,}500$ PSI

WALL CROSS-SECTIONAL AREA:

$A = \frac{C}{f_c} = \frac{16010}{16500} = 0.97$ SQ IN/FT REQUIRED

FROM TABLE [illegible]-2
FOR $t = 0.138$ IN, $A = 2.003$ SQ IN/FT
10 GAGE

HANDLING STIFFNESS:

$FF = \frac{D^2}{EI} = \frac{117^2}{30 \times 10^6 \times 0.0781} = 0.017 < 0.020$ [illegible]

BY R.G.B. DATE 2 MAY 74 SUBJECT BENNVILLE SHEET NO. 2 OF
CHKD. BY G.H. DATE 6/5/74 PROTECTIVE WORKS D.M. JOB NO.
40.19

PIPE ARCH CULVERT (CONT)

16'-5" x 9'-11" (CONT)

BOLTED SEAM STRENGTH:

31,000 LB/FT > 16,010 LB/FT O.K.

CORNER BEARING PRESSURE ON SOIL:

$$P_c = P_v \frac{R_t}{R_c} = \frac{1950(197)}{18(2)} = 10,670 \text{ PSF}$$

SPAN 12'-4", RISE 7'-9"

HEIGHT OF COVER = 14'

DESIGN PRESSURE:

$P_v = K(DL + LL)$

$DL = HW = 14(130) = 1820$ PSF

K = 0.86 FIG. 3-5

LL < 100 PSF NEGLECT TABLE 3-1

$P_v = 0.86(1820) = 1565$ PSF

RING COMPRESSION:

$$C = P_v \frac{S}{2} = 1565\left(\frac{12.33}{2}\right) = 9650 \text{ LB/FT}$$

ALLOWABLE WALL STRESS:

$f_b = 33,000$ PSI FIG. 3-6

$$f_c = \frac{f_b}{2} = \frac{33,000}{2} = 16,500 \text{ PSI}$$

BY R.G.B. DATE 2 MAY 74 SUBJECT BERNVILLE SHEET NO. 3 OF

CHKD. BY DATE PROTECTIVE WORKS D.M. JOB NO.

9.20

PIPE ARCH CULVERT (CONT)

12'-4" X 7'-9" (CONT)

WALL CROSS-SECTIONAL AREA:

$$A = \frac{C}{f_c} = \frac{9650}{16,500} = 0.585 \quad \text{SQ. IN/FT REQUIRED}$$

FOR $t = 0.109$ in, $A = 1.556$ SQ. IN./FT.
12 GAGE

HANDLING STIFFNESS:

$$FF = \frac{D^2}{EI} = \frac{148^2}{30\times10^6\times0.0604} = 0.012 < 0.020 \quad O.K.$$

BOLTED SEAM STRENGTH:

TABLE 3-3

21,000 LB/FT > 9650 LB/FT O.K.

CORNER BEARING PRESSURE ON SOIL:

$$P_c = P_v \frac{R_t}{R_c} = 1565 \frac{(148)}{(18)2} = 6434 \text{ PSF}$$

DOUBLE PIPE ARCH CULVERT

SPAN 9'-4", RISE 6'-3"
HEIGHT OF COVER = 19'

DESIGN PRESSURE:

$P_V = K(DL + LL)$

$DL = HW = 19(130) = 2470$ PSF.

$K = 0.86$ NEGLECT LL

$P_V = 0.86(2470) = 2124$ PSF.

RING COMPRESSION:

$C = P_V \frac{S}{2} = 2124\left(\frac{9.33}{2}\right) = 9908$ LB/FT.

ALLOWABLE WALL STRESS:

$f_c = \frac{f_y}{2} = \frac{33,000}{2} = 16,500$ PSI

WALL CROSS-SECTIONAL AREA:

$A = \frac{C}{f_c} = \frac{9908}{16,500} = 0.60$ SQ. IN./FT REQ'D

FOR t = 0.109 IN. A = 1.556 SQ. IN./FT.
12 GAGE

HANDLING STIFFNESS:

$FF = \frac{D^2}{EI} = \frac{112^2}{30 \times 10^6 \times 0.0604} = 0.007 < 0.020$ O.K.

BOLTED SEAM STRENGTH:

21,000 LB/FT > 9908 LB/FT O.K.

BY R.G.B. DATE 15 MAY 74 SUBJECT BERNVILLE SHEET NO. 5 OF
CHKD. BY G.H. DATE 6/5/74 PROTECTIVE WORKS D.M. JOB NO.
pg. 22

DOUBLE PIPE ARCH CULVERT (CONT)

9'-4" X 6'-3" (CONT)

CORNER BEARING PRESSURE ON SOIL:

$$P_c = P_v \frac{R_t}{R_c} = \frac{2124(112)}{(18)^2} = 6608 \text{ PSF.}$$

SPAN 11'-10", RISE 7'-7"
HEIGHT OF COVER = 15'

DESIGN PRESSURE:

$$P_v = K(DL + LL)$$

$$DL = Hw = 15(130) = 1950 \text{ PSF}$$

$K = 0.86$ NEGLECT LL

$$P_v = 0.86(1950) = 1677 \text{ PSF.}$$

RING COMPRESSION:

$$C = P_v \frac{S}{2} = 1677\left(\frac{11.83}{2}\right) = 9919 \text{ LB/FT.}$$

ALLOWABLE WALL STRESS:

$$f_c = \frac{f_b}{2} = \frac{33,000}{2} = 16,500 \text{ PSI}$$

WALL CROSS-SECTIONAL AREA:

$$A = \frac{C}{f_c} = \frac{9919}{16,500} = 0.60 \text{ SQ. IN./FT.}$$

FOR $t = 0.109$ IN. $A = 1.556$ SQ IN/FT
12 GAGE

DOUBLE PIPE ARCH CULVERT (CONT)

11'-10" X 7'-7" (CONT)

HANDLING STIFFNESS:

$$FF = \frac{D^2}{EI} = \frac{142^2}{30 \times 10^6 \times 0.0604} = 0.011 < 0.020 \text{ O.K.}$$

BOLTED SEAM STRENGTH:

21,000 LB/FT > 9919 LB/FT O.K.

CORNER BEARING PRESSURE ON SOIL:

$$P_c = P_v \frac{R_t}{R_c} = \frac{1677(142)}{(18)2} = 6615 \text{ PSF}$$

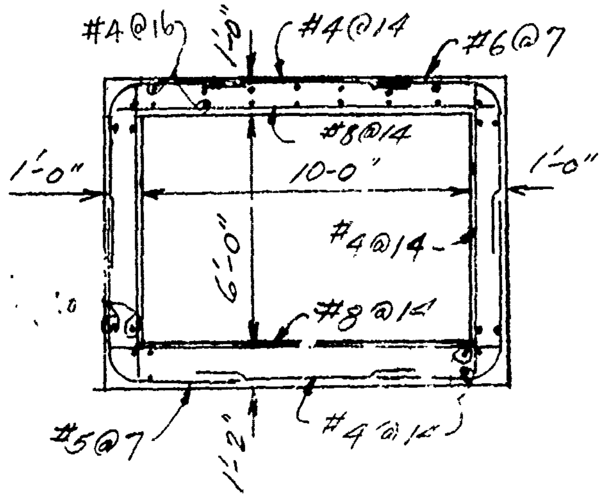
BY K.G.B. DATE 29 APR 74 SUBJECT BERNVILLE SHEET NO. 1 OF

CHKD. BY G.H. DATE 6/5/74 PROTECTIVE WORKS D.M. JOB NO.

pg. 2A

BOX CULVERT

HEIGHT OF FILL = 19 FT



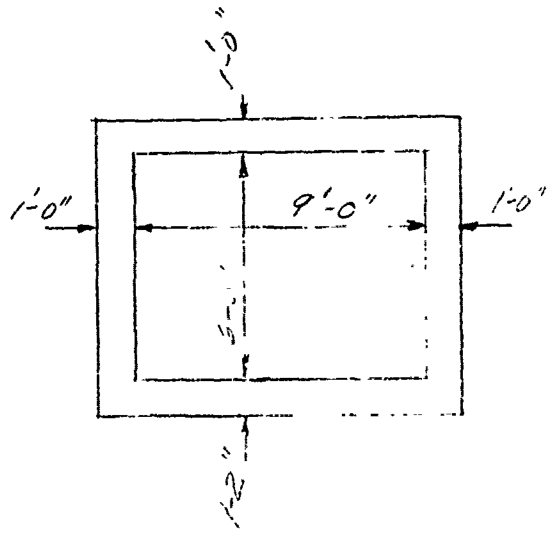
REF:- PEINDOOT

BC-132

BASE PRESSURE

[1.17(12) + 1([illegible]) [illegible]] · $\frac{150}{12}$

+ 19(.120) = [illegible] KSF



SAME PRESS. AS 10X6 SECTION

BY HSR DATE JUL 74 — SUBJECT BLUE MARSH LAKE — SHEET NO. ____ OF ____
CHKD. BY R.G.B. DATE AUG 74 — BERNVILLE PROT. WORKS — JOB NO. ____
SANITARY EFFLUENT LINE — pg. 25

EXISTING LINE: 10" V.C. ; $n = .013$; $S = .014$

AT FULL FLOW,

$$R_h = \frac{\pi r^2}{2\pi r} = \frac{r}{2} = 0.2084'$$

by Kutter Formula

$$V_F = \frac{\frac{1.81}{.013} + 41.66}{1 + \frac{.013(41.66)}{\sqrt{.2084}}} \sqrt{(.2084)(.014)}$$

$$V_F = \frac{180.891}{2.186}(.0540) = 4.47 \text{ FPS}$$

$$Q_F = \pi(.416)^2(4.47) = 2.44 \text{ CFS}$$

PROPOSED DIVERSION LINE: $n = .013$, $S = .0045$

TRY 12" AT FULL FLOW,

$$R_h = \frac{r}{2} = 0.250'$$

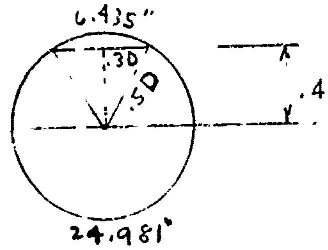
$$V_F = \frac{\frac{1.81}{.013} + 41.66}{1 + \frac{.013(41.66)}{\sqrt{.25}}} \sqrt{(.250)(.0045)}$$

$$V_F = \frac{180.891}{2.083}(.0335) = 2.91 \text{ FPS}$$

$$Q_F = \pi(.50)^2(2.91) = 2.29 \text{ CFS} \sim 2.44$$ 12" OK

10" Effluent line ; $n = .013$; $S = .014$

For $\frac{d}{D} = 0.9$



$.5\measuredangle = 36.86989764°$

$\measuredangle = 73.73979529°$

$\frown = 6.435"$

$C = 31.416"$

$A = 78.5398\ in^2$

$A = \frac{73.73979529}{360}\pi(5)^2 = 16.0875$

$- 12.0000$

$= 4.0875$

$= 74.4523 = 0.517\ SF$

$R_h = \frac{74.4523}{24.981} = 2.9804" = 0.2483'$

By Kutter Formula

$$V_F = \frac{\frac{1.81}{.013} + 41.66}{1 + \frac{.013(41.66)}{\sqrt{.2483}}}\sqrt{(0.2483)(.014)}$$

$$\frac{180.8908}{1 + \frac{0.54158}{.49830}}\sqrt{.003476}$$

$86.6808(.05896) = 5.1106\ FPS$

$Q_{.9} = 0.517 \times 5.1106 = 2.642\ CFS$

Try 12" Effluent line ; $n = .013$; $S = .0045$

$$V_F = \frac{180.8908}{2.0869}\sqrt{(0.2483)(.0045)} = 86.6808(.03343) = 2.8975$$

$A = 0.7854(2.8975) = 2.28\ CFS$

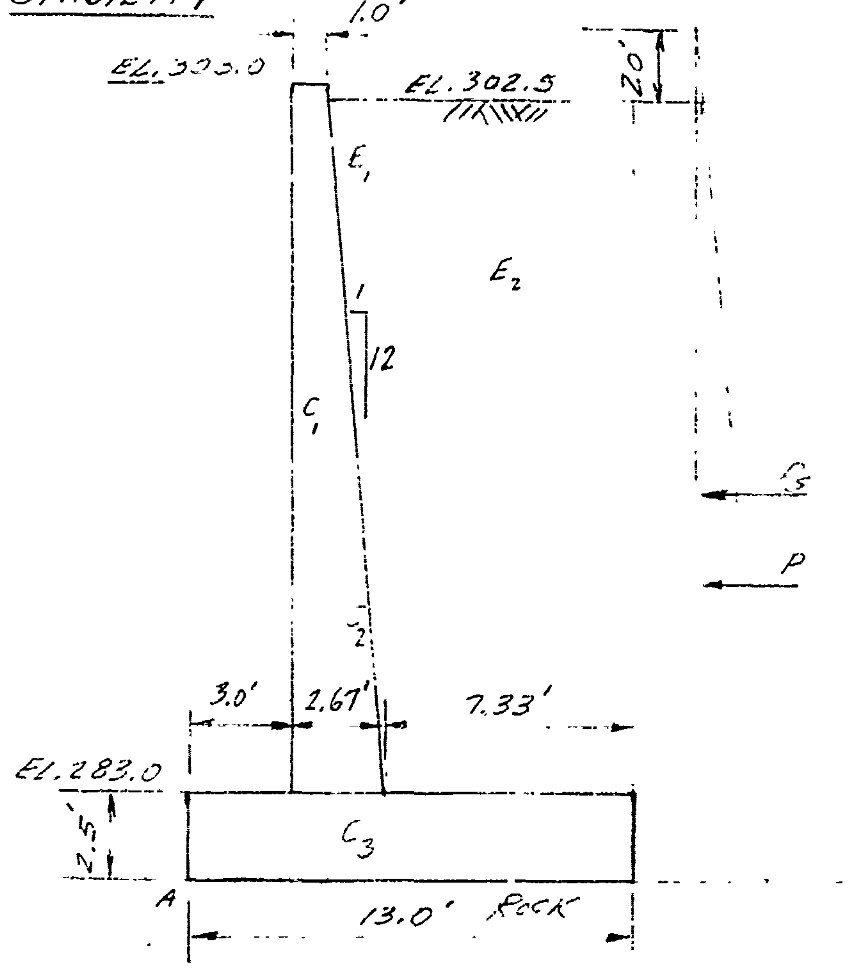
BY K.G.? DATE 10 AUG 74 SUBJECT BERRYVILLE SHEET NO. 1 OF

CHKD. BY G.H. DATE 9/4/74 PROTECTIVE WORKS D.M. JOB NO.

RETAINING WALL AT [illegible] STA. pg. 27

E. SIDE

STABILITY



NOTE: SURCHARGE FROM SUB-STATION

ITEM	DESCRIPTION	H →	V ↓	L.A.	M_A
C_1	1.0 (20)(.150)		3.0	3.5	10.5
C_2	1.67(20)(.5)(.150)		2.51	4.56	11.42
C_3	2.5 (13.0)(.150)		4.88	6.5	31.69
E_1	1.63(19.5)(.5)(.125)		1.99	5.13	10.19
E_2	7.33(19.5)(.125)		17.87	9.34	166.90
P_S	2.0(.125)(.6)(22.0)	-3.3		11.0	-36.3
P	$(22.0)^2$(.125)(.6)(.5)	-18.15		8.36	-151.73
	TOTAL	-21.45	30.25		42.65

$$\bar{X} = \frac{\Sigma M_A}{\Sigma V} = \frac{42.65}{30.25} = 1.41'$$

BASE PRESSURE

$$P_A = \frac{2(30.25)}{3(1.41)} = 14.3 \text{ KSF} < 20 \text{ KSF O.K.}$$

BY K.G.B. DATE 21AUG74 SUBJECT BERNVILLE PROTECTIVE WORKS D.M. RETAINING WALL AT PUMP STA. E. SIDE

CHKD. BY C.H. DATE 9/4/74

SHEET NO. 2 OF

JOB NO. pg. 28

STABILITY (CONT)

SHEAR-FRICTION SAFETY FACTOR

$$S_{s-f} = \frac{\Sigma V \tan\phi + 2SD}{\Sigma H} = \frac{30.25(1) + 2(5)(2.5)}{21.45} = 2.67 > 1.5 \quad O.K.$$

REINF.

$f'_c = 3000$ PSI $\quad f_c = .35 f'_c = 1050$ PSI $\quad f_s = 20,000$ PSI

STEM

AT EL. 283.0

$M = 2.0(.125)(.6)(19.5)^2(\frac{1}{2}) + (19.5)^3(.125)(.6)(\frac{1}{2})(.38)$

$M = 134.2'K$

$V = 2.0(.125)(.6)(19.5) + (19.5)^2(.125)(.6)(\frac{1}{2})$

$V = 17.2\ K$

$N = 3.0 + 2.51 + 1.99 = 7.5\ K$

$d = 27.5$ in. $\quad d' = 4.5$ in $\quad d'' = 11.5$ in.

$e = \frac{12M}{N} + d'' = \frac{12(134.2)}{7.5} + 11.5 = 226.2$ in. $\qquad \frac{e}{d} = \frac{226.2}{27.5} = 8.23$

$E = \frac{e}{12} = \frac{226.2}{12} = 18.85$ FT.

$K = 152 \quad F = 0.757$

$KF = 152(0.757) = 115.0$

$NE = 7.5(18.85) = 141.4$

$NE - KF = 26.4$

COMP. REINF. REQ'D

$\frac{d'}{d} = \frac{4.5}{27.5} = 0.164 \qquad c = 0.63$

$A'_s = \frac{NE - KF}{cd} = \frac{26.4}{0.63(27.5)} = 1.52\ in^2$

USE #11 @ 12

BY R.G.B. DATE 21AUG74 SUBJECT BERNVILLE SHEET NO. 3 OF

CHKD. BY G.H. DATE 9/4/74 PROTECTIVE WORKS D.M. JOB NO.

RETAINING WALL AT PUMP STA. 10.29

E. SIDE

REINF. (CONT)

STEM (CONT)

AT EL. 283.0 (CONT)

$L_d = 0.02\, f_y\, d_b / \sqrt{f'_c} = 0.02(40{,}000)(1.41)/\sqrt{3000}$

$L_d = 21$ in.

$0.0003\, f_y\, d_b = 0.0003(40{,}000)(1.41) = 17$ in O.K.

$j = .891$ $i = 1.13$

$A_s = \dfrac{NE}{a d i} = \dfrac{141.4}{1.44(27.5)(1.13)} = 3.16$ in^2.

USE #8 @ 3

$v = \dfrac{V}{b d} = \dfrac{17{,}200}{12(27.5)} = 52 < 60$ O.K.

$L_d = 0.04\, A_b\, f_y / \sqrt{f'_c} = 0.04(0.79)(40{,}000)/\sqrt{3000}$

$L_d = 23$ in.

TEMP. REINF.

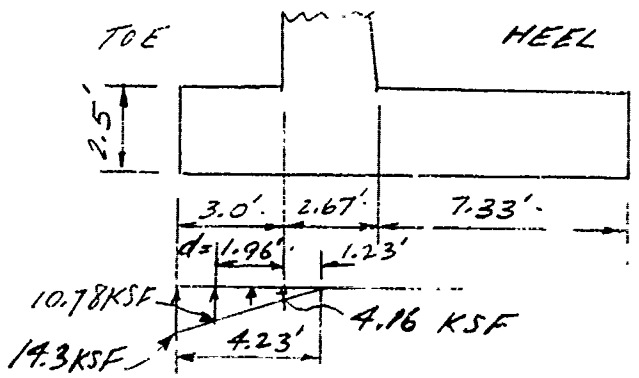
$A_s = 0.001(32)(12) = 0.38$ in^2

USE #6@12

BY R. G. B. DATE 21 AUG 74 SUBJECT BERNVILLE
CHKD. BY G. H. DATE 9/3/74 PROTECTIVE WORKS D.M.
RETAINING WALL AT PUMP STA. E. SIDE

SHEET NO. 4 OF
JOB NO.
pg. 30

REINF. (CONT)



$$\frac{14.3(1.23)}{4.23} = 4.16\ KSF$$

$$\frac{14.3(3.19)}{4.23} = 10.78\ KSF.$$

TOE

$M = 4.16(3.0)^2(\tfrac{1}{2}) + (14.3 - 4.16)(3.0)^2(\tfrac{1}{2})(\tfrac{2}{3}) - 2.5(3.0)^2(.150)(\tfrac{1}{2})$

$M = 47.4'K$

$V = 4.16(3.0) + (14.3 - 4.16)(3)(\tfrac{1}{2}) - 2.5(3.0)(.150)$

$V = 26.5K$

$V_d = 10.78(1.04) + (14.3 - 10.78)(1.04)(\tfrac{1}{2}) - 2.5(1.04)(.150)$

$V_d = 12.6\ K$

$d = 23.5\ in. \quad d' = 4.5\ in.$

$K = 152 \quad F = 0.553$

$KF = 152(0.553) = 84.1$

$$A_s = \frac{M}{a d} = \frac{47.4}{1.44(23.5)} = 1.40\ in^2.$$

USE #11 @ 12

$$v = \frac{V_d}{b d} = \frac{12,600}{12(23.5)} = 45 < 60 \quad O.K.$$

$L_d = 46\ in.$

HOOK REQ'D

$f_h = \xi\sqrt{f'_c} = 360\sqrt{3000} = 19,718$

$L_e = 0.04 A_b f_h / \sqrt{f'_c} = 0.04(1.56)(19,718)/\sqrt{3000}$

$L_e = 22\ in$

BY R.G.B. DATE 21AUG74 SUBJECT BERNVILLE SHEET NO. 5 OF

CHKD. BY G.H. DATE 9/3/74 PROTECTIVE WORKS D.M. JOB NO.

RETAINING WALL AT PUMP STA. E. SIDE pg. 31

REINF. (CONT)

HEEL

$M = (19.5)(7.33)^2(.125)(\frac{1}{2}) + 2.5(7.33)^2(.150)(\frac{1}{2})$

$M = 75.6'^K$

$V = 19.5(7.33)(.125) + 2.5(7.33)(.150)$

$V = 20.6^K$

$d = 25.5 in \quad d' = \overset{4.5}{6.5} in.$

$K = 152 \quad F = 0.651$

$KF = 152(0.651) = 99.0$

$A_s = \frac{M}{a\,d} = \frac{75.6}{1.44(25.5)} = 2.06 \; in^2$

USE #8 @ 4

$V_d = 5.20(19.5)(.125) + 2.5(5.20)(.150)$

$v = \frac{V_d}{bd} = \frac{14,630}{12(25.5)} = 48 < 60 \; O.K. \qquad V_d = 14.63^K$

$L_d = 23(1.4) = 32 \; in$

TEMP. REINF.

$A_s = 0.001(30)(12) = 0.36 \; in^2$

USE #6 @ 12

BY R.G.B. DATE 21AUG74 SUBJECT BERNVILLE PROTECTIVE WORKS D.M. RETAINING WALL AT PUMP STA. E. SIDE

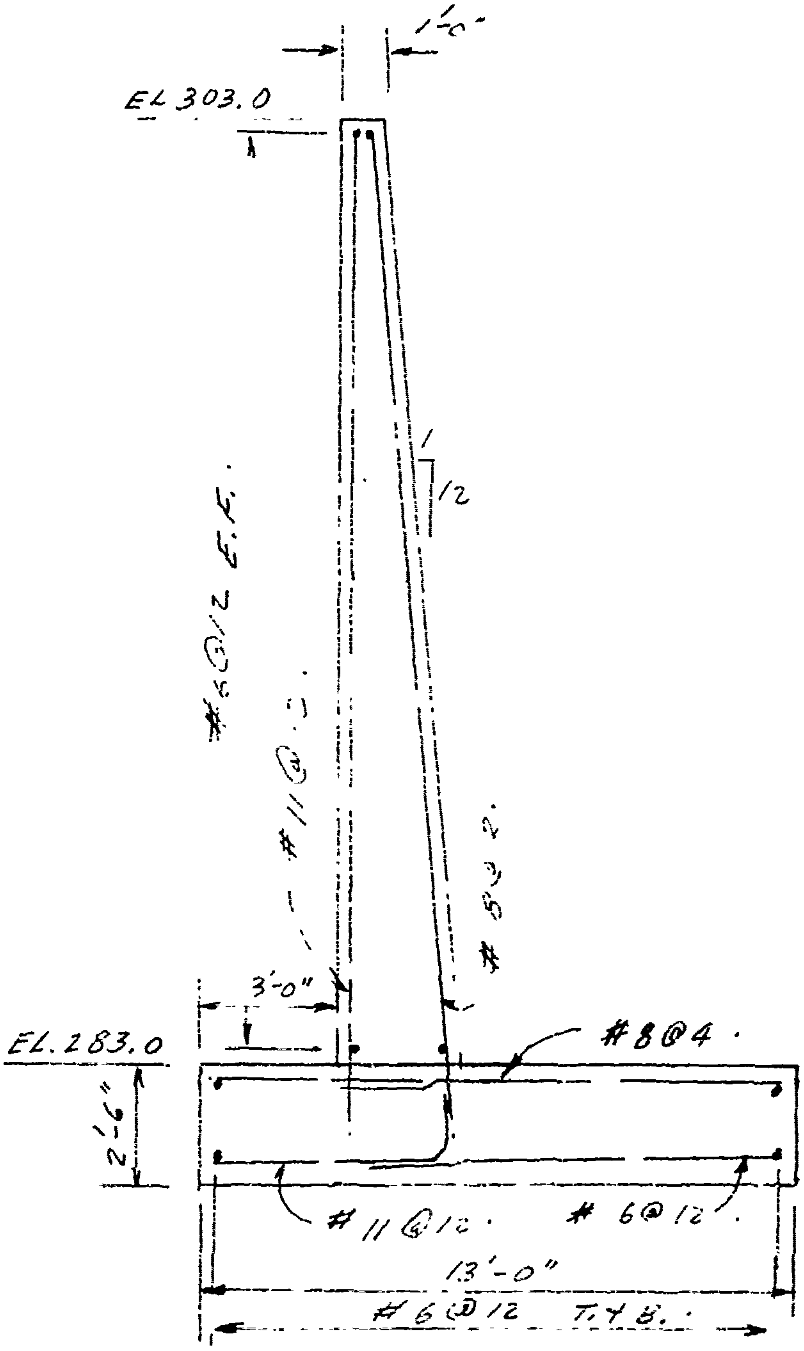
CHKD. BY G.H. DATE 9/4/74

SHEET NO. 6 OF

JOB NO.

pg. 32

REINF. (CONT)



BY W.J.G. DATE 29 JULY 74 SUBJECT BERNVILLE

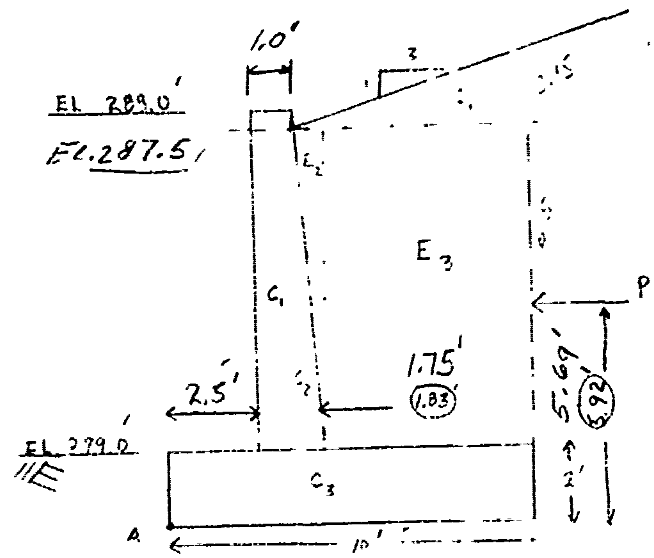
CHKD. BY P.G.B. DATE 14 AUG 74 PROTECTIVE WORKS D.M.

RETAINING WALL AT PUMP STA W. SIDE

SHEET NO. 1 OF 2

JOB NO.

pg. 33



AT REST PRESSURE FOR SLOPING BACKFILL

$$K_0 = TAN^2 (45° - \phi/2)$$

$$.6 = TAN^2 (45° - \phi/2)$$

$$0.774597 = TAN (45 - \phi/2)$$

$$37° - 46' = 45° - \phi/2$$

$$7° 14' = \phi/2$$

$$14° 28' = \phi'$$

$$TAN\ i = 1/3$$

$$i = 18° 26' \qquad \delta = 0°$$

$\beta = 90°$

$\beta - \phi = 75° 32'$

$\phi' + \delta = 14° 28'$

$\beta - i = 71° 34'$

$\phi' - i =$ SAY $0°$ $(3° 58')$

$\beta + \delta = 90°$

BY WJG DATE [illegible] SUBJECT BERNVILLE SHEET NO. 2 OF 2

CHKD. BY RGB DATE [illegible] PROTECTIVE WORKS D.M. JOB NO.

RETAINING WALL AT PUMP STA. pg. 34

W. SIDE

[illegible]

$$K_r = \left[\frac{[illegible]\beta \ \sin(\beta - \delta)}{[illegible](\beta + \delta) + \sqrt{\frac{[illegible](\delta + \phi)\,[illegible](\delta - i)}{[illegible](\beta - i)}}} \right]^2$$

$$K_r = \left[\frac{1\,(.769)}{[illegible] + \sqrt{[illegible]}} \right]^2$$

$K_r =$ [illegible]

ITEM	DESCRIPTION		H →	V ↓	L.A.	M_A
C_1	(1)(9)([illegible])	=		1.35	3.0	4.05
C_2	.75 (.83)(9)(.150)	=		1.12 1.01	3.27 3.15	[illegible] 3.30
C_3	(2)(10)(.1[illegible])	=		3.00	5.[illegible]	[illegible]
E_1	(6.46)(2.15)(½)(.125)	=		.97	7.90	6.79
E_2	(8.[illegible])(.[illegible])(½)(.125)	=		.42 .38	4.13	1.69 1.52
E_3	([illegible])(5.[illegible])(.125)	=	−9.40	6.02 6.11	7.16	43.13 43.74
[illegible]	3.13 (.125)(34)(½) 12.65	=	10.16		5.92 5.89	−60.15 −[illegible].49
	TOTAL		10.16 −9.40	9.29 12.72		10.17 21.41

$$\bar{x} = \frac{\Sigma M_A}{\Sigma V} = \frac{10.17 \ \ 21.41}{9.29 \ \ 12.72} = 1.09 \ \ 1.68$$

BASE PRESSURE — $P_A = \dfrac{9.29\ 12.72\,(2)}{1.09\ 1.68\,(3)} = 5.69 \ \ 5.05$ KSF

SLIDING

$$S_{s-f} = \frac{\Sigma V \tan\phi + c\,SD}{\Sigma H} = \frac{12.72\,(1) + 2(5)(2)}{9.40}$$

$S_{s-f} = 3.5 < 1.5$ O.K.

BY ______ DATE 29 ______ 74 SUBJECT BERNVILLE SHEET NO. 3 OF __
CHKD. BY R.S.S. DATE 14/__ PROTECTIVE WORKS D.M. JOB NO. ______
RETAINING WALL AT PUMP STA. pg. 35
W. SIDE

REINFORCING –

$f_c' = 3000$ psi .35 (3000) =
$f_s = 20,$ psi

STEM

AT EL 379.0

$M = (8.5)^3(.14)(.12)(1/2)(\ldots)$

$M = 16.23$ K-FT

$V = (8.5)^2 \ldots (.125)(1/2)$

$V = 4.24$ k

$N = \ldots + 1.12 + \ldots$ = 1.39 k
(1.12 → 1.1; → .38; 1.39 → 2.74)

$e = \frac{12M}{N} - \ldots$ = $\frac{(16.23)}{(1.39)}$ + 4.24 6.0 (1.39 → 2.74)

$e = \ldots + 4.2 \ldots$ = $\ldots$ 77.08 6.0

$\frac{\ldots}{\ldots} = \frac{77.08}{\ldots}$ = 4.67 16.5

$F = \ldots - \frac{77.08}{\ldots}$ = 6.92

$K = 150$ $F =$ 0.272

$NE = (2.74)(6.92)$ = 17.54
$KF = (150)(.272)$ = 41.34

$j = .911$ $k =$ 1.24

$A_s = \frac{NE}{\ldots}$ = $\frac{17.59}{\ldots}$ = .60 in²

\# @ 12"

$v = \frac{V}{bd} = \frac{4240}{12(16.5)}$ = 21 p <

EMBED < = 17.5 in.

BY W.E.G. DATE 29 JULY 74 SUBJECT BERNVILLE SHEET NO. 4 OF 8

CHKD. BY E.G.R. DATE 15 AUG 74 PROTECTIVE WORKS D.M. JOB NO.

RETAINING WALL AT PUMP STA. pg. 36

W. SIDE

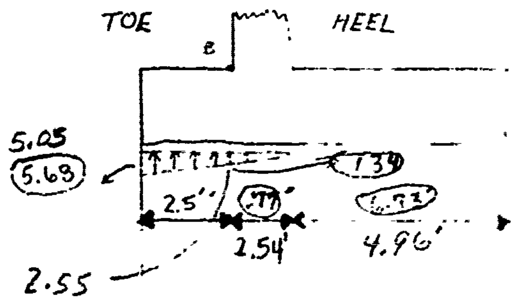
REINF.

TEMP. REINF

21 .25

$A_s = .001\,(21.9)(12) = (.27)\ in^2$

Use # 5 @ 12"



$5.05 \dfrac{(2.54)}{5.04} = 2.55$

TOE

2.55 5.05 2.55

$M_B = (1.39)(2.5)^2(1/2) + (5.68 - 1.39)(2.5)^2(1/2)(2/3) -$

$(2.0)(.150)(2.5)^2(1/2)$

7.97 5.21

$M_B = 4.17 + (8.95) - .94$

12.78

$M_B = (12.22)$ K-FT

2.55 5.05 2.55

$V = (1.39)(2.5) + (5.68 - 1.39)(2.5)(1/2) - 2.0(.150)(2.5)$

6.38 3.13

$V = 3.35 + (5.42) - .75$

8.76

$V = (8.02)$ K $\quad d = 17.5"$

$.1' = 4.5"$

$K = 152 \qquad F = .306$

$KF = (152)(.306) = 46.51$

12.78 0.51

$A_s = \dfrac{M}{ad} = \dfrac{(12.20)\ K\text{-}FT}{(1.44)(17.5)} = (.49)\ in^2$

Use # 7 @ 12"

8760 42

$v = \dfrac{V}{bd} = \dfrac{(8,020)}{12(17.5)} = (38) < 60 \quad$ O.K.

EMBED = ~~17.9~~ (18.7")

BY WJG DATE 30 JULY 74 SUBJECT BERNVILLE SHEET NO. 5 OF 6

CHKD. BY R.G.B. DATE 15 AUG 74 PROTECTIVE WORKS D.M. JOB NO.

RETAINING WALL AT PUMP STA. pg. 37

W. SIDE

REINF.

HEEL

$M = (.92)(\overset{5.75}{6.73})^2(.125)(\tfrac{1}{2}) + 2(.150)(\overset{5.75}{6.73})^2(\tfrac{1}{2})$

$M = \overset{20.29}{27.80} + \overset{4.96}{6.79} = \cancel{34.59}\ 25.25$

$V = (.92)(\overset{5.75}{6.73})(.25) + 2(.150)(\overset{5.75}{6.73})$

$V = \overset{7.06}{8.26} + \overset{1.73}{2.02} = 10.28\ 8.79$

$d = \overset{11.5}{17.5}''$ $d' = \overset{6.5}{4.5}''$

$K = .380$

$KF = 46.51\ 57.76$

$A_s = \frac{M}{ad} = \frac{\overset{25.25}{\cancel{34.59}}}{144\ \underset{19.5}{(17.5)}} = \overset{0.90}{1.37}\ in^2$

Use # $\overset{8}{9}$ @ 9 10

$v = \frac{V}{bd} = \frac{\cancel{10,280}\ 8790}{(12)(\underset{11.5}{17.5})} = \overset{38}{49} < 60\ psi$

$e_{mbed} = 23(1.4) = 33\ in$

HOOK REQ'D

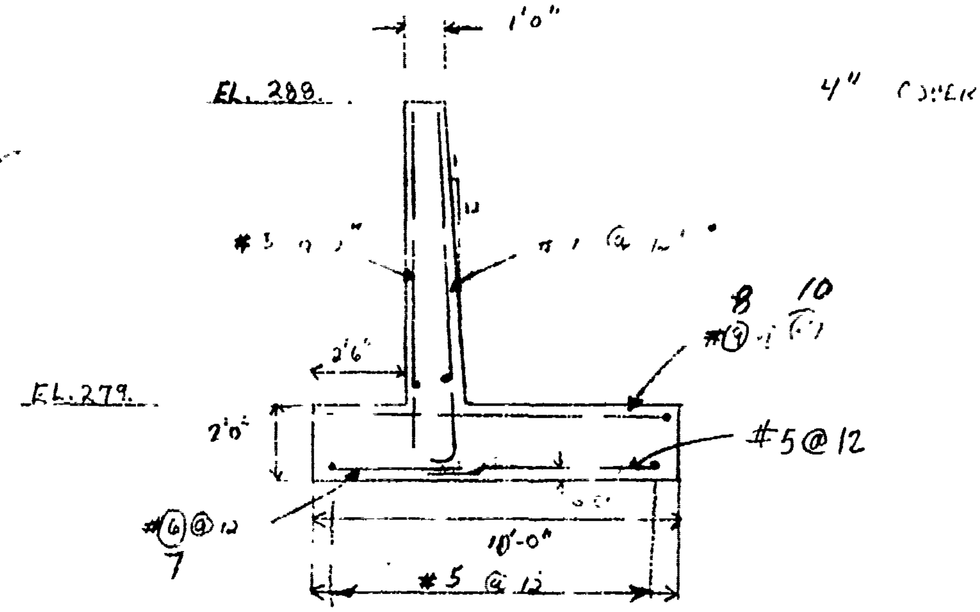
$f_h = \xi\sqrt{f'_c} = 360\sqrt{3000} = 19,718$

$l_e = 0.04\ A_b f_h / \sqrt{f'_c} = 0.04(0.79)(19,718)/\sqrt{3000}$

$l_e = 11\ in.$

USE 22 in + STD HOOK

BY WDG DATE 30 JULY 74 SUBJECT BERNVILLE SHEET NO. 6 OF 6
CHKD. BY R.G.B. DATE 15 AUG 74 PROTECTIVE WORKS D.M. JOB NO.
RETAINING WALL AT PUMP ST. pg. 38
W. SIDE



BY R.G.B. DATE 9 MAY 74 SUBJECT BERNVILLE SHEET NO. 1 OF
CHKD. BY G.N. DATE 6/5/74 PROTECTIVE WORKS D.M. JOB NO.
GRAVITY OUTLET AT PUMP STA pg. 39

BOX

DESIGN CRITERIA

REFERENCES

1) EM 1110-2-2902
2) EM 1110-1-2101
3) EM 1110-2-2103

LOAD CONDITIONS

LOAD COND. I — DEAD LOADS; SUBMERGENCE LINE IN FILL TO EL. 317.5; NO WATER INSIDE; VERT. LOAD FACTOR = 1.5; HORIZ. LOAD FACTOR = 0.5

LOAD COND. II — DEAD LOADS; VERT. LOAD FACTOR = 1.5; HORIZ. LOAD FACTOR = 0.5

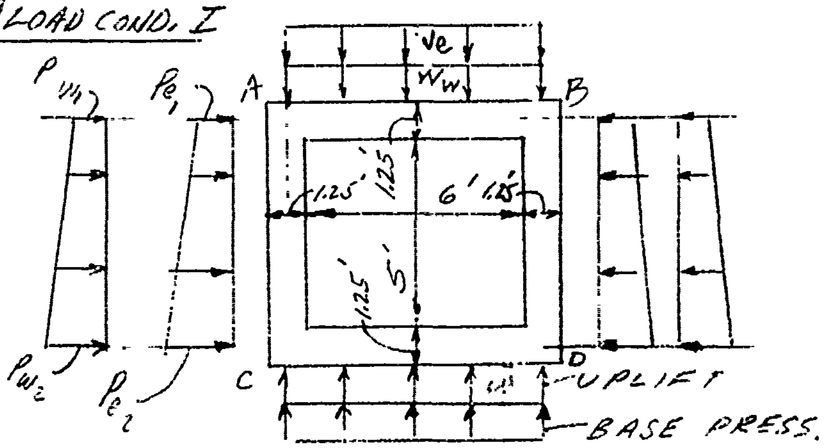
BY R.G.B. DATE 9 MAY 74 SUBJECT BERNVILLE SHEET NO. 2 OF

CHKD. BY G.H. DATE 6/6/74 PROTECTIVE WORKS D.M. JOB NO.

GRAVITY OUTLET AT PUMP STA pg. 40

BOX

LOAD COND. I



$W_W = 0.0625(26) = 1.63$ KSF

$W_e = 1.5\ \gamma H_h = 1.5(.0675)(26) = 2.63$ KSF

$P_{e_1} = 0.5\ \gamma H = 0.5(.0675)(23) = 0.78$ KSF

$P_{e_2} = 0.5(.0675)(29) = 0.98$ KSF

$P_{W_1} = (.0625)(20) = 1.25$ KSF

$P_{W_2} = (.0625)(26) = 1.63$ KSF

$U = 27.25(.0625) = 1.70$ KSF

BASE PRESSURE $= 2.63 + \left[1.25(8.5)(2) + 5(1.25)(2)\right]\dfrac{.150}{8.5}$ (21.25, 12.5)

$= 3.23$ KSF

$FEM_{AB} = FEM_{BA} = \frac{1}{12}wL^2 = \frac{(1.63+2.63)}{12}(7.25)^2 = 18.66$ 'K

$FEM_{AC} = FEM_{BD} = \frac{L^2}{60}(2P_2 + 3P_1) = \frac{(6.25)^2}{60}\left[2(2.61) + 3(2.03)\right] = 7.36$ 'K

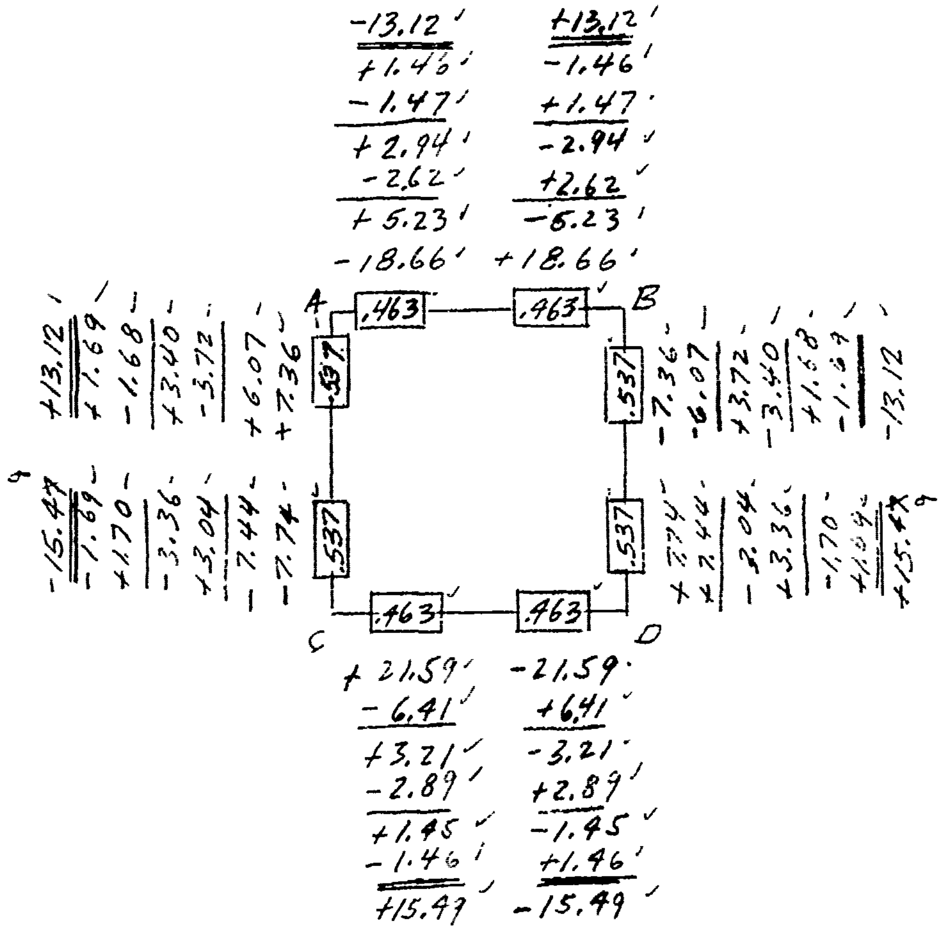
$FEM_{CA} = FEM_{DB} = \frac{L^2}{60}(3P_2 + 2P_1) = \frac{(6.25)^2}{60}\left[3(2.61) + 2(2.03)\right] = 7.74$ 'K

$FEM_{CD} = FEM_{DC} = \frac{1}{12}(4.93)(7.25)^2 = 21.59$ 'K

BY R.G.B. DATE 9 MAY 74 SUBJECT BERNVILLE SHEET NO. 3 OF
CHKD. BY G.H. DATE 6/6/74 PROTECTIVE WORKS D.M. JOB NO.
GRAVITY OUTLET AT PUMP STA pg. 41

BOX (CONT)

LOAD COND I (CONT)

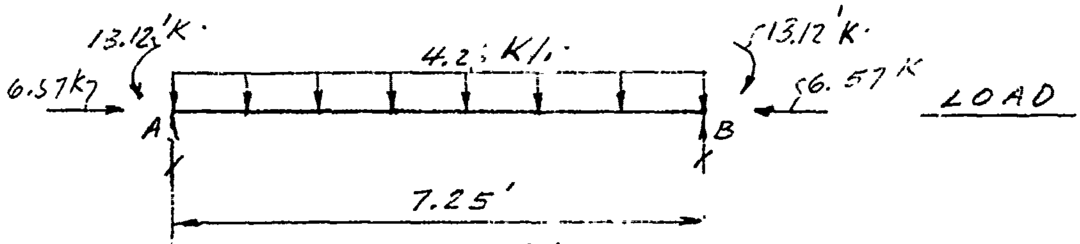


DL for AB & CD & their respective FEM should be adjusted

BOX (CONT)

LOAD COND. I (CONT)

MEMBER AB



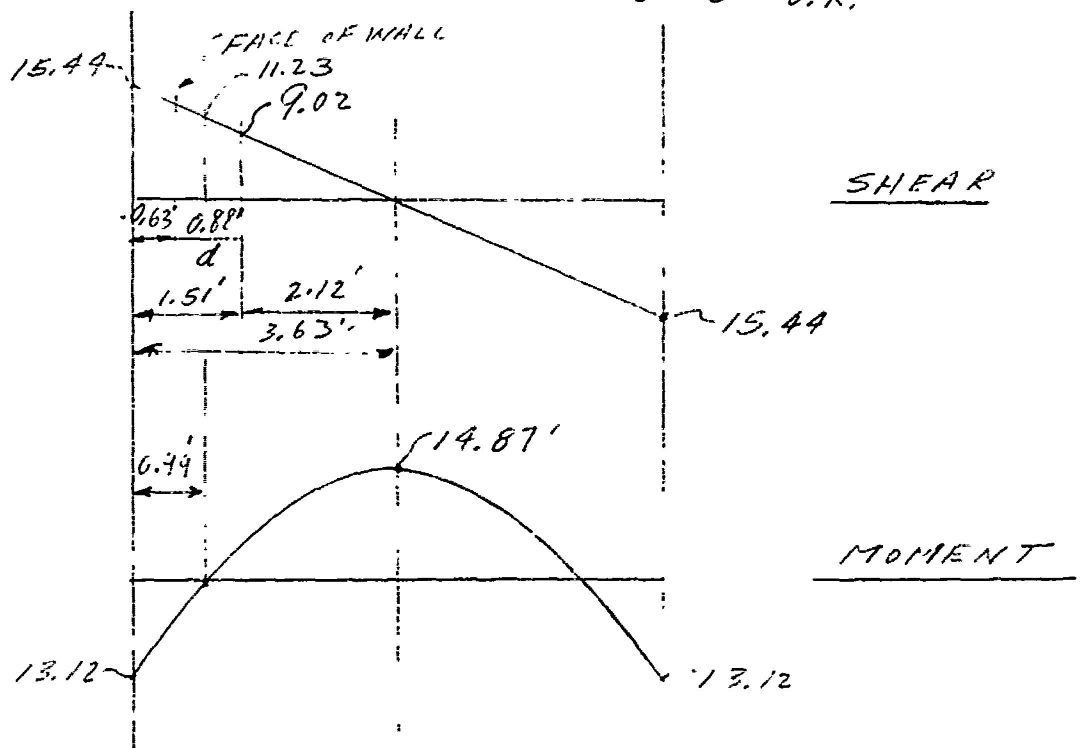
$$\Sigma M_A = -13.12 + \overset{111.96}{4.26\left(\frac{7.25}{2}\right)^2} + 13.12 - 7.25 R_B = 0$$

$$R_B = \frac{111.96}{7.25} = 15.44\,K$$

$$R_A = 15.44\,K$$

CHECK $\Sigma F = 4.26(7.25) - 2(15.44) = 0$

$0 = 0$ O.K.



$$M_{MID\ SPAN} = 15.44\left(\frac{7.25}{2(2)}\right) - 13.12 = 14.87'K$$

$$V_d = \frac{15.44(2.12)}{3.63} = 9.02\,K$$

$$V_{FACE} = \frac{15.44(3.0)}{3.63} = 12.76\,K$$

BY R.G.B. DATE 16 MAY 74 SUBJECT BERNVILLE SHEET NO. 4A OF

CHKD. BY G.H. DATE 6/6/74 PROTECTIVE WORKS D.M. JOB NO.

GRAVITY OUTLET AT PUMP STA pg. 43

BOX (CONT)

LOAD COND I (CONT)

MEMBER AB (CONT)

DIST FROM SUPPORT TO ZERO MOMENT (POINT OF CONTRAFLEXURE)

$$15.44X - \frac{15.44X^2}{3.63(2)} = 13.12$$

$$X^2 - 7.26X + 6.17 = 0$$

$$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{7.26 \pm \sqrt{(-7.26)^2 - 4(6.17)}}{2(1)}$$

$$X = 0.90'$$

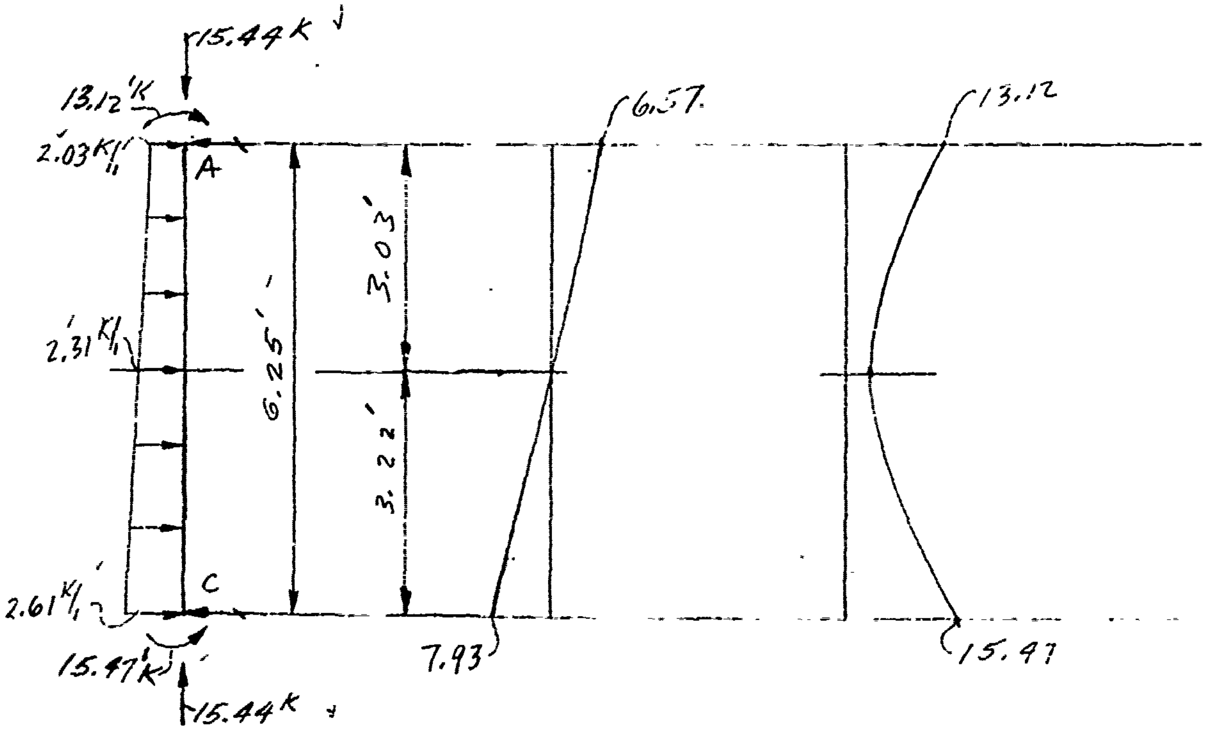
SHEAR AT POINT OF CONTRAFLEXURE

$$V_c = \frac{15.44(2.64)}{3.63} = 11.23\ K$$

BOX (CONT)

LOAD COND. I (CONT)

MEMBER AC



LOAD SHEAR MOMENT

$$\Sigma M_A = 13.12 - 2.03\left(\frac{6.25}{2}\right)^2 - (2.61-2.03)\left(\frac{6.25}{3}\right)^2 - 15.47 + 6.25R_c = 0$$

39.65 7.55

$$R_c = \frac{49.55}{6.25} = 7.93^K$$

$$\Sigma M_c = -15.47 + 2.03\left(\frac{6.25}{2}\right)^2 + 0.58\left(\frac{6.25}{6}\right)^2 + 13.12 - 6.25R_A = 0$$

39.65 3.78

$$R_A = \frac{41.08}{6.25} = 6.57^K$$

CHECK $\Sigma F = 2.03(6.25) + 0.58\left(\frac{6.25}{2}\right) - 7.93 - 6.57 = 0$

12.69 1.81

$0 = 0$ O.K.

DIST FROM A TO ZERO SHEAR

$$6.57 - 2.03X - \frac{0.58X^2}{6.25(2)} = 0'$$

.0464

$$X^2 + 43.75X - 141.59 = 0$$

$$X = \frac{-b \pm \sqrt{b^2-4ac}}{2a} = \frac{-43.75 \pm \sqrt{43.75^2 - 4(-141.59)}}{2} = \frac{-43.75 + 49.8}{2}$$

$X = 3.03'$

BOX (CONT)

LOAD COND. I (CONT)

MEMBER AC (CONT)

$$M_{MIN\ NEG} = -15.47 + 7.93\overset{25.53}{(3.22)} - 0.30\overset{1.04}{\left(\frac{3.22}{3}\right)^2} - 2.31\overset{11.98}{\left(\frac{3.22}{2}\right)^2}$$

$$= -2.96'K$$

BY R.G.B. DATE 10 MAY 74 SUBJECT BERNVILLE SHEET NO. 7 OF ____
CHKD. BY G.A. DATE 6/6/74 PROTECTIVE WORKS D.M. JOB NO. ____
GRAVITY OUTLET AT PUMP STA pg. 46

BOX (CONT)

LOAD COND I (CONT)

MEMBER AB

AT SUPPORT

$f'_c = 3000$ PSI $\quad f_c = 0.35 f'_c = 1050$ PSI
$f_s = 20{,}000$ PSI
$d = 10.5$ in. $\quad d' = 4.5$ in. $\quad d'' = 3.0$ in. $\quad t = 15.0$ in.

$M = 13.12$ FT-KIPS
$N = 6.57$ KIPS

4 in. COVER BOTH FACES

$$e = \frac{12M}{N} + d'' = \frac{12(13.12)}{6.57} + 3.0 = 26.96 \text{ in.}$$

$$\frac{e}{d} = \frac{26.96}{10.5} = 2.57 \qquad j = 0.891$$

$$E = \frac{e}{12} = \frac{26.96}{12} = 2.25 \text{ FT.}$$

$K = 152 \qquad F = 0.110$

$NE = 6.57(2.25) = 14.78$
$KF = 152(0.110) = 16.72$

NO COMP. REINF. REQ'D

$i = 1.53$

$$A_s = \frac{NE}{adi} = \frac{14.78}{1.44(10.5)(1.53)} = 0.64 \text{ in}^2 \quad .62$$

1.48

USE # 6 @ 8

BOX (CONT)

LOAD COND I (CONT)

MEMBER AB (CONT)

AT SUPPORT (CONT)

SHEAR

$$V_{pc} = 11,000 \frac{(.046 + p)(12 + N/V)}{(19 + l'/d)} \sqrt{\frac{f'_c}{4000}}$$

$$p = \frac{A_s}{bd} = \frac{0.66}{12(10.5)} = 0.005$$

$$V_{pc} = 11,000 \frac{(.046 + .005)(12 + \frac{6.57}{11.23})}{19 + \frac{5.27(12)}{10.5}} \sqrt{\frac{3000}{4000}}$$

F.S. = 2.5

$V_{pc} = 244$ psi

$$\frac{V_{pc}}{F.S.} = \frac{244}{2.5} = 98 \text{ psi}$$

$$v = \frac{V}{bd} = \frac{11,230}{12(10.5)} = 89 \text{ psi} < 98 \text{ psi O.K.}$$

TEMP. REINF.

TRANSVERSE $A_s = .002\, bt = .002(12)(15) = 0.36 \text{ in}^2$

USE #6 @ 12

LONGITUDINAL $A_s = .001\, bt = .001(12)(15) = 0.18 \text{ in}^2$

USE #4 @ 12

BOX (CONT)

LOAD COND I (CONT)

MEMBER AB (CONT)

AT MID SPAN

$$e = \frac{12M}{N} + d'' = \frac{12(14.87)}{6.57} + 3.0 = 30.16 \text{ IN.}$$

$$\frac{e}{d} = \frac{30.16}{10.5} = 2.87$$

$$E = \frac{e}{12} = \frac{30.16}{12} = 2.51 \text{ FT.}$$

$K = 152$ $F = 0.110$

$NE = 6.57(2.87) = 18.86$
$KF = 152(0.110) = 16.72$
$NE - KF = 2.14$

COMP. REINF. REQ'D

$i = 1.45$

$$A_s = \frac{NE}{a d i} = \frac{18.86}{1.44(10.5)(1.45)} = 0.86 \text{ IN}^2$$

USE #9 @ 12

BOX (CONT)

LOAD COND I (CONT)

MEMBER AC

AT A

$$e = \frac{12M}{N} + d'' = \frac{12(13.12)}{15.44} + 3.0 = 13.20 \text{ IN.}$$

$$\frac{e}{d} = \frac{13.20}{10.5} = 1.26$$

$$E = \frac{e}{12} = \frac{13.20}{12} = 1.10 \text{ FT.}$$

$K = 152$ $F = 0.110$

$NE = 15.44(1.10) = 16.98$
$KF = 152(0.110) = 16.72$

NO COMP. REINF REQ'D ok.

$i' = 3.41$

$$A_s = \frac{NE}{adi} = \frac{16.98}{1.44(10.5)(3.41)} = 0.33 \text{ IN}^2$$

USE #6 @ 12

AT C

$$e = \frac{12M}{N} + d'' = \frac{12(15.47)}{15.44} + 3.0 = 15.02 \text{ IN.}$$

$$\frac{e}{d} = \frac{15.02}{10.5} = 1.43$$

$$E = \frac{e}{12} = \frac{15.02}{12} = 1.25 \text{ FT.}$$

$K = 152$ $F = 0.110$

$NE = 15.44(1.25) = 19.30$
$KF = 152(0.110) = 16.72$ COMP REINF. REQ'D
$NE - KF = 2.58$

BOX (CONT)

LOAD COND I (CONT)

MEMBER AC (CONT)

AT C

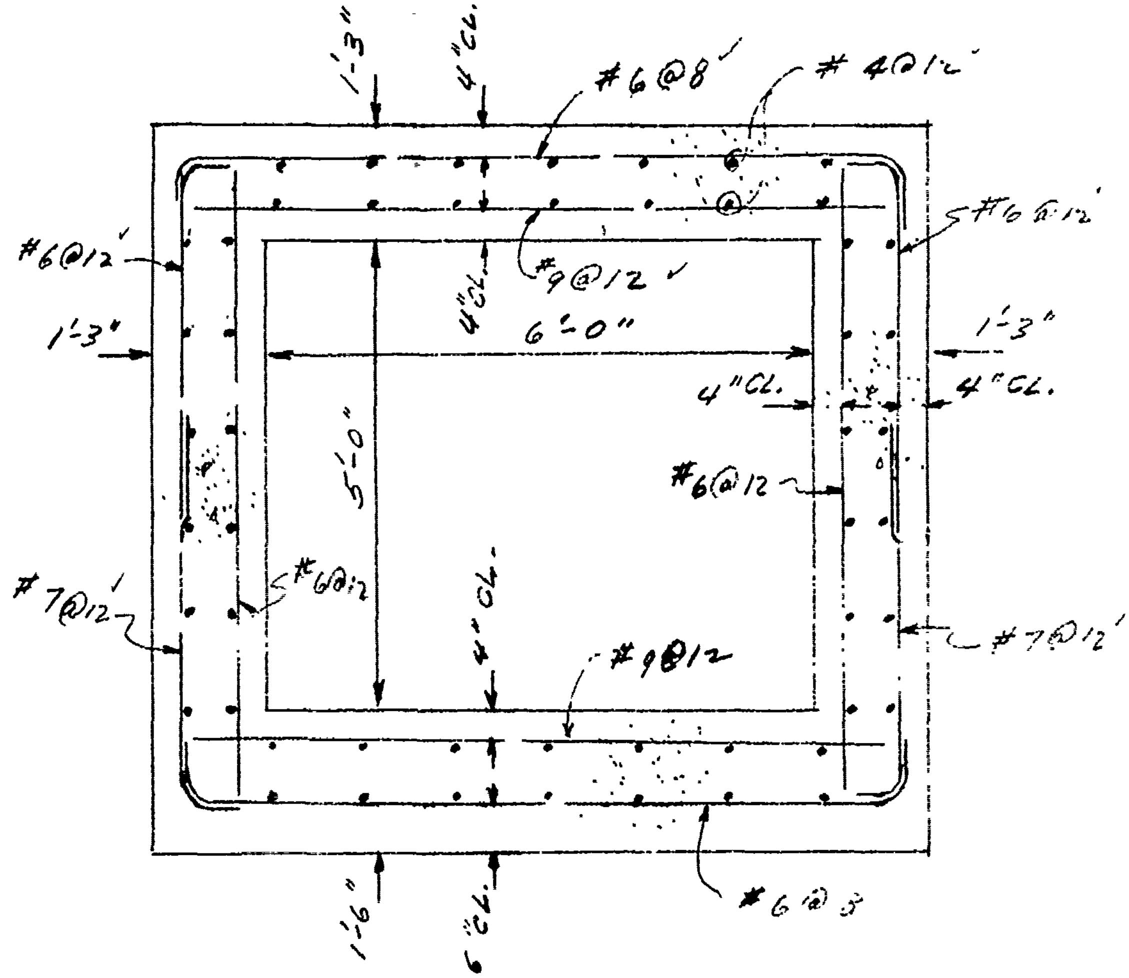
$i = 2.65$

$$A_s = \frac{NE}{a\,d\,i} = \frac{19.30}{1.44(10.5)(2.65)} = 0.48 \ \text{IN}^2$$

USE #7 @ 12

BY R.G.B. DATE 16 MAY 74 SUBJECT BERNVILLE SHEET NO. 11 OF
CHKD. BY G.H. DATE 6/6/74 PROTECTIVE WORKS D.M. JOB NO.
GRAVITY OUTLET AT PUMP STA pg 51

BOX (CONT)



72"Ø R.C.P.

LOAD COND. I

USE FIRST CLASS BEDDING

$$F_p = \frac{1.431}{X_p - X_a k} = \frac{1.431}{0.707 - 0.549(.33)} = 2.72$$

$$W_e = 1.5\,\gamma\, b_c\, H = \overset{15.94}{1.5(.0675)(7)(22.5)} + \overset{4.10}{1.5(.130)(7)(3)} + \overset{1.59}{0.0625(25.5)}$$

$$W_e = 21.63\ K/FT = 21,630\ LB/FT$$

$$D\text{-}LOAD = \frac{W_e \times SF}{ID \times F_p} = \frac{21,630(2.0)}{6\,(2.72)} = 2651\ LB/FT/FT\ OF\ DIAM.$$

REF. - ASTM SPEC C-76

USE CLASS V R.C.P.

D-LOAD TO PRODUCE A 0.01 IN. CRACK = 3000 LB/FT/FT OF DIA.

FOR 72 in D.

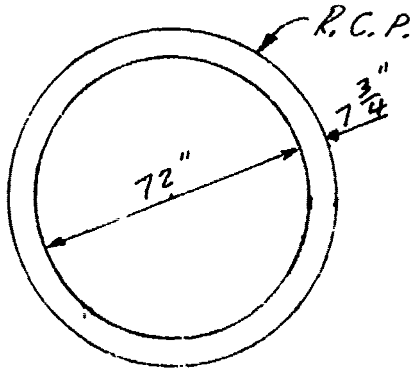
THICKNESS OF WALL = $7\frac{3}{4}$ in

f'_c = 6000 PSI

REINF.

0.99 INNER CAGE

0.74 OUTER CAGE



BY R.G.B. DATE 21 MAY 74 SUBJECT BERNVILLE SHEET NO. 13 OF
CHKD. BY G.H. DATE 6/7/74 PROTECTIVE WORKS D.M. JOB NO.
GRAVITY OUTLET AT PUMPSTA pg 53

3 - 36" D. R.C.P.'s

LOAD COND. I

USE FIRST CLASS BEDDING

$$F_p = \frac{1.431}{X_p - X_a k} = \frac{1.431}{0.707 - \underset{.425}{0.856}(.33)} = 3.37$$

$$W_e = 1.5\, \gamma\, b_c\, H_h = 1.5(67.5)(3.5)(24.0) + 1.5(130)(3.5)(3.0) + 62.5(27.0)$$

8505   2048   1688

$$W_e = 12,241 \text{ LB/FT}'$$

$$D\text{-}LOAD = \frac{W_e \times SF}{ID \times F_p} = \frac{12,241(2.0)}{3(3.37)} = 2422 \text{ LB/FT/FT OF DIAM.}$$

USE CLASS V R.C.P.

BY R.G.B. DATE MAY 74 SUBJECT BERNVILLE PROTECTIVE WORKS D.M. GRAVITY OUTLET AT PUMP STA

CHKD. BY ______ DATE ______

SHEET NO. ______ OF ___

JOB NO. ______ PG. 54

COST COMPARISON

5'x6' REINF. CONCRETE BOX

INCLUDES O.H. + PROFIT. THIS DOES NOT INCLUDE EXCAVATION, BEDDING, BACKFILL, HEADWALLS. JUST IN PLACE.

$30,800

72" Ø RCCP, CLASS V

SAME CONITIONS AS BOX	$12,900
72" Ø FLAP VALVE (W/O INSTALL. & OPERATOR)	$8,900
72" Ø SLUICE GATE " "	$13,600
TOTAL	$35,400

3-36" Ø RCCP, CLASS V

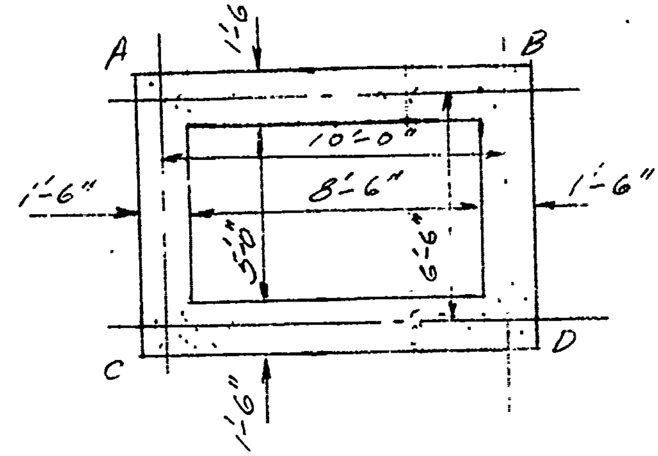
SAME CONDITIONS AS BOX	$10,600
3-36" Ø FLAP VALVES (W/O INSTALL. & OPERATOR)	$10,800
3-36" Ø SLUICE GATES " "	18,900
TOTAL	$40,300

BY R.G.B. DATE 20 MAY 74 SUBJECT BENVILLE SHEET NO. 1 OF

CHKD. BY G.H. DATE 6/7/74 PROTECTIVE WORKS D.M. JOB NO.

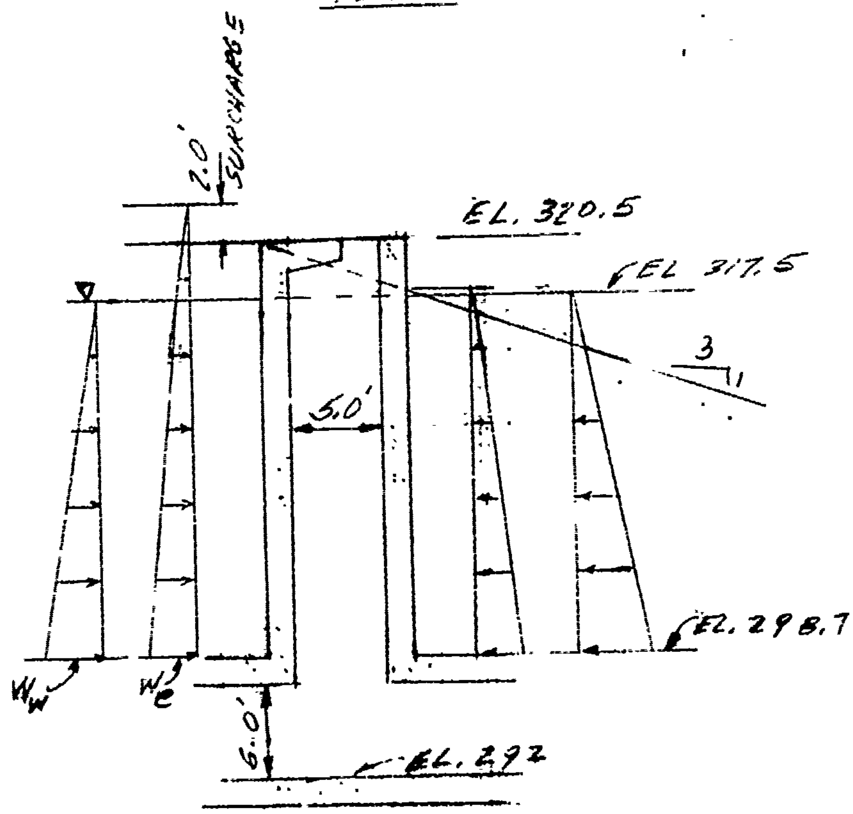
GRAVITY OUTLET AT PUMP pg 55

GATEWELL



PLAN

LOAD COND. — DEAD LOAD; LIVE LOAD; SUBMERGENCE LINE TO EL. 317.5; NO WATER INSIDE



ASSUME EARTH PRESSURE SAME ALL AROUND, BASED ON HIGH SIDE.

$k_r = 0.7$ $\gamma_{MOIST} = 130\ LB/FT^3$ $\gamma_{SUB} = 72.5\ LB/FT^3$

AT EL. 298.7

$$W_e = 5\underbrace{(0.130)(0.7)}_{.455} + \underbrace{0.0725(18.8)(0.7)}_{.954} = 1.41\ KSF$$

$$W_W = 18.8(0.0625) = 1.18\ KSF$$

$$W_{TOTAL} = 1.18 + 1.41 = 2.60\ KSF$$

GATEWELL (CONT)

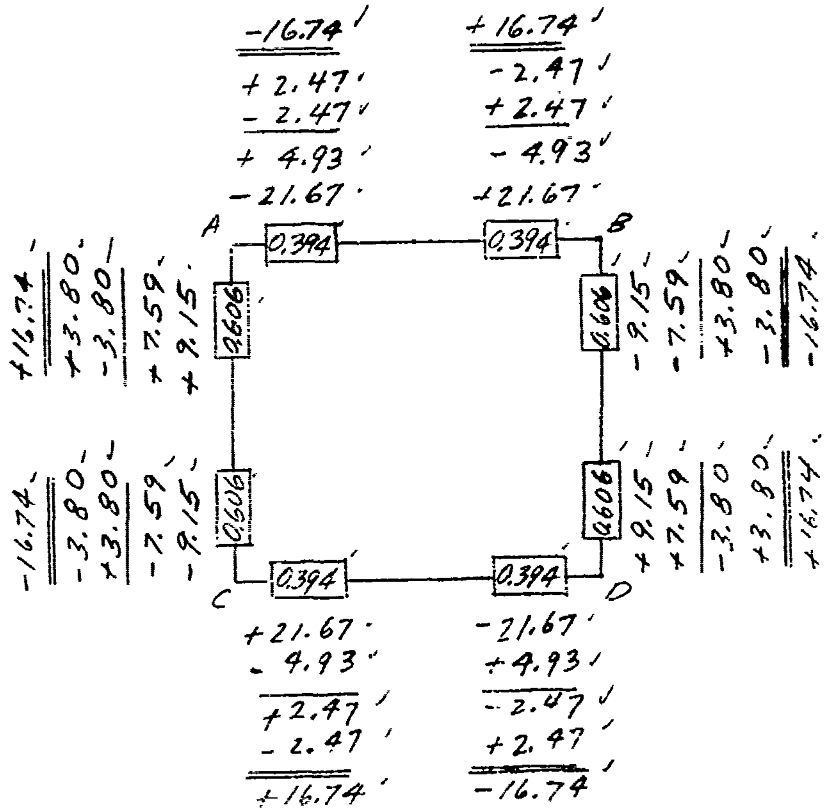
$K_{AB} = \frac{1}{10} = 0.100 \qquad K_{BC} = \frac{1}{6.5} = 0.154$

$DF_{AB} = \frac{0.100}{0.100 + 0.154} = 0.394$

$DF_{AC} = \frac{0.154}{0.254} = 0.606$

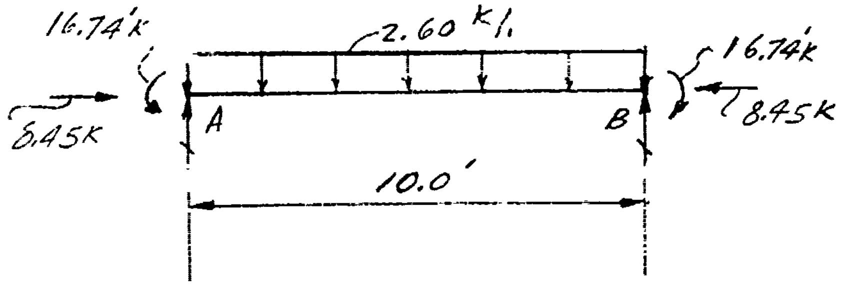
$FEM_{AB} = \frac{wL^2}{12} = \frac{2.60\,(10)^2}{12} = 21.67\ K''$

$FEM_{AC} = 2.60\,\frac{(6.5)^2}{12} = 9.15\ K''$



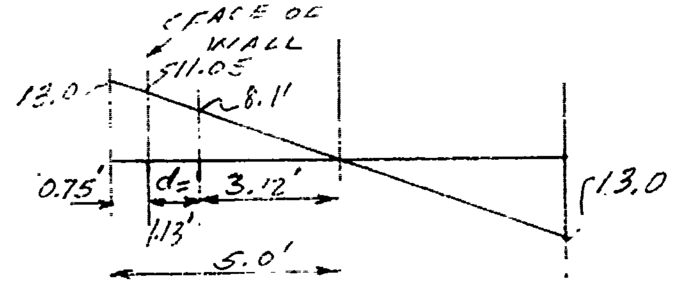
GATEWELL (CONT)

MEMBER AB

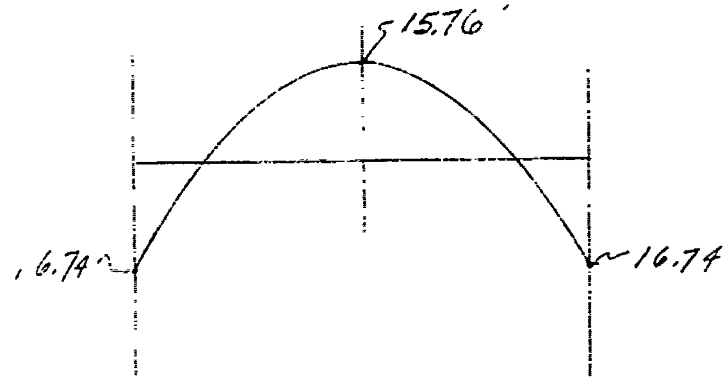


LOAD

$R_A = R_B = 2.60\frac{(10)}{2} = 13.0^{K}$



SHEAR



MOMENT

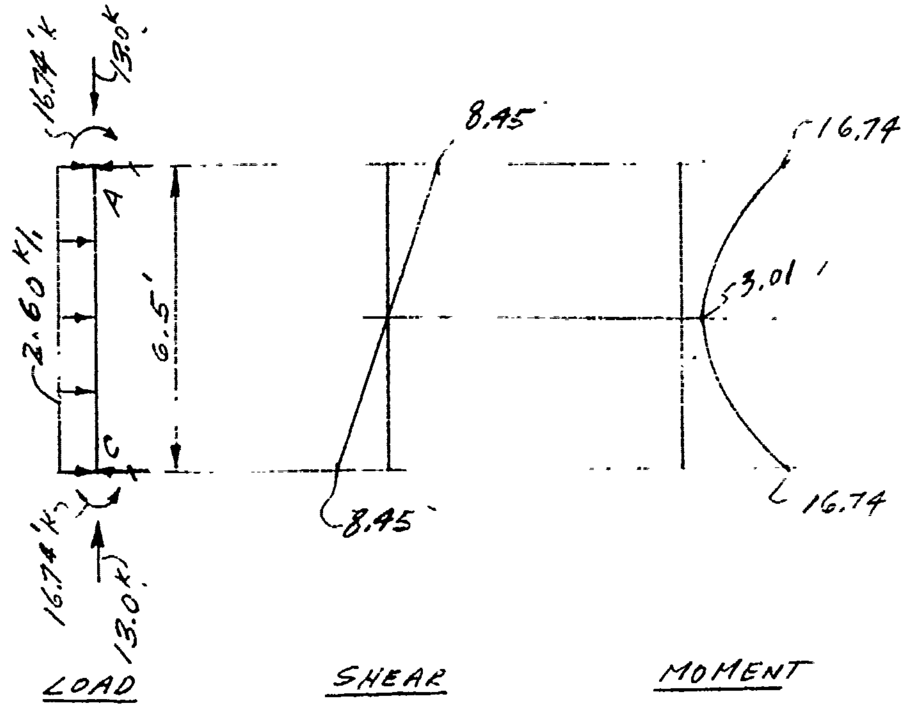
$M_{MID\ SPAN} = 13.0(5.0)(0.5) - 16.74 = 32.50 - 16.74 = 15.76'^{K}$

$V_{WALL\ FACE} = \frac{13.0(4.25)}{5.0} = 11.05^{K}$

$V_d = \frac{13.0(3.12)}{5.0} = 8.11^{K}$

GATEWELL (CONT)

MEMBER AC



$$R_A = R_C = 2.60\frac{(6.5)}{2} = 8.45^K$$

$$M_{MIDSPAN} = 8.45\frac{(3.25)}{2} - 16.74 = 13.73 - 16.74 = -3.01'^K$$

BY R.G.B. DATE 21 MAY 74 SUBJECT BERNVILLE SHEET NO. 5 OF

CHKD. BY G.H. DATE 6/7/74 PROTECTIVE WORKS D.M. JOB NO.

GRAVITY OUTLET AT PUMP STA

GATEWELL (CONT)

MEMBER AB

AT SUPPORT

$M = 16.74\ 'K$ $\quad f'_c = 3000\ psi$ $\quad f_s = 20,000\ psi$

$N = 8.45\ K$ $\quad f_c = 0.35 f'_c = 1050\ psi$

$d = 13.5\ in.$ $\quad d' = 4.5\ in.$ $\quad d'' = 4.5\ in.$

$$e = \frac{12M}{N} + d'' = \frac{12(16.74)}{8.45} + 4.5 = 28.3\ in. \qquad \frac{e}{d} = \frac{28.3}{13.5} = 2.09$$

$$E = \frac{e}{12} = \frac{28.3}{12} = 2.36\ FT. \qquad j = 0.871$$

$K = 152$ $\quad F = 0.182$

$NE = 8.45(2.36) = 19.9$

$KF = 152(0.182) = 27.7$

NO COMP. REINF. REQ'D

$i = 1.75$

$$A_s = \frac{NE}{a d i} = \frac{19.9}{1.44(13.5)(1.75)} = 0.58\ in^2$$

USE #7 @ 12

$$v = \frac{V}{bd} = \frac{8110}{12(13.5)} = 50\ psi < 60\ psi \quad O.K.$$

$L_d = 18\ in$

HOOK REQ'D

$f_h = \xi\sqrt{f'_c} = 360\sqrt{3000} = 19,718$

$L_d = 0.04 A_b f_h / \sqrt{f'_c} = 0.04(0.6)(19718)/\sqrt{3000} = 9\ in$

USE 18 in + STD HOOK

GATEWELL (CONT)

MEMBER AB (CONT)

AT MIDSPAN

$M = 15.76\ 'K$
$N = 8.45\ K$

$e = \frac{12M}{N} + d'' = \frac{12(15.76)}{8.45} + 4.5 = 26.88$ IN.

$\frac{e}{d} = \frac{26.88}{13.5} = 1.99$

$E = \frac{e}{12} = \frac{26.88}{12} = 2.24$ FT.

$j = 0.891$

$K = 152 \qquad F = 0.182$

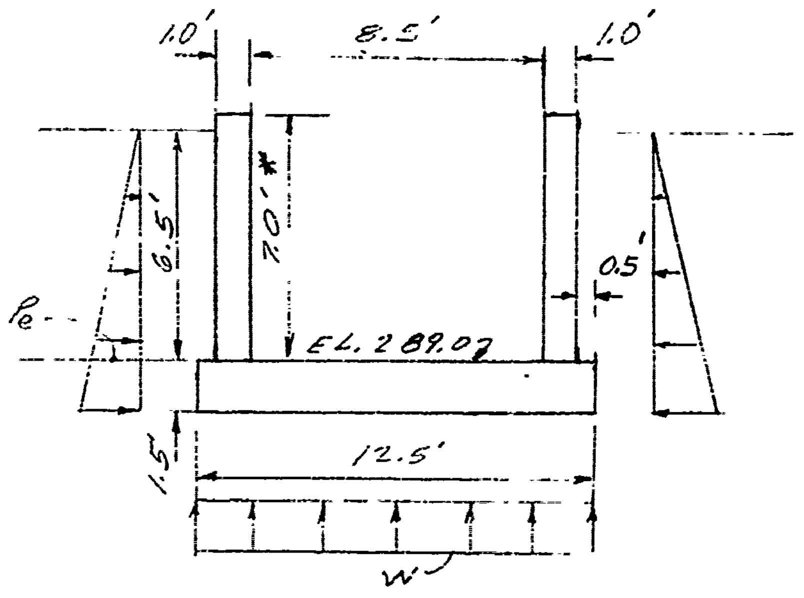
$NE = 8.45(2.24) = 18.9$
$KF = 152(0.182) = 27.7$

$i = 1.31$

$A_s = \frac{NE}{adi} = \frac{18.9}{1.44(13.5)(1.81)} = 0.54\ IN^2$

USE # 7 @ 12

HEADWALL - RIVER SIDE



* USE $\frac{2}{3}$ OF MAX HEIGHT FOR AVERAGE DESIGN HEIGHT (SEE DWG)

$\gamma_{NAT} = 125$ PCF $\quad \gamma_{SAT} = 135$ PCF $\quad K_r = 0.6$

$P_e = 6.5(.125)(0.6) = 0.49$ KSF

$W = \{[1(7)(2) + 12.5(1.5)].150 + 6.5(.5)(2)(.125)\}/12.5$

$= 0.43$ KSF

STEM

AT EL. 289.0

$M = (6.5)^2(0.49)(\frac{1}{6}) = 3.45'^K$

$N = 7.0(1.0)(.150) = 1.05^K$

$V = 6.5(.49)(\frac{1}{2}) = 1.59^K$

$f'_c = 3000$ PSI $\quad f_c = 0.35 f'_c = 1050$ PSI $\quad f_s = 24{,}000$ PSI

$d = 7.5$ in. $\quad d'' = 1.5$ in.

USE 4 in. CLEAR COVER BOTH FACES

BY R.G.B. DATE 5 JUNE 74 SUBJECT BERNVILLE SHEET NO. 8 OF
CHKD. BY E.H. DATE 6/7/74 PROTECTIVE WORKS D.M. JOB NO.
GRAVITY OUTLET AT PUMP STA pg. 62

HEADWALL - RIVER SIDE (CONT)

STEM (CONT)

$e = \frac{12M}{N} + d'' = \frac{12(3.45)}{1.05} + 1.5 = 40.9$ in. $\frac{e}{d} = \frac{40.9}{7.5} = 5.45$

$E = \frac{e}{12} = \frac{40.9}{12} = 3.41$ FT.

$K = 152$ $F = 0.056$ $j = 0.891$

$NE = 1.05(3.41) = 3.58$
$KF = 152(0.056) = 8.51$

NO COMP. REINF. REQ'D.

$i = 1.20$

$A_s = \frac{NE}{\mathrm{j} d i} = \frac{3.58}{1.44(7.5)(1.20)} = 0.28$ in²

USE #5 @ 12

$v = \frac{V}{bd} = \frac{1590}{12(7.5)} = 18$ PSI < 60 PSI O.K.

$L_d = 10$ in.

TEMP. REINF.

$A_s = 12(12)(.0020)(\frac{1}{2}) = 0.14$ in²

USE #4 @ 12

BY R.G.B. DATE 5 JUNE 74 SUBJECT BERNVILLE SHEET NO. 9 OF

CHKD. BY G.H. DATE 6/7/74 PROTECTIVE WORKS O.M. JOB NO.

GRAVITY OUTLET AT PUMP STA pg. 63

HEADWALL - RIVERSIDE (CONT)

SLAB

AT ENDS

$M = (7.25)^3(.125)(0.\ldots)(\frac{1}{6}) = 4.76\ 'k'$

$R = V = [0.46 - 1.5(.150)]\ 9.5(\frac{1}{2}) = 1.09\ k$

$N = (8.0)^2(.125)(0.6)(\frac{1}{2}) = 2.40\ k$

$d = 11.5\ in. \quad d'' = 2.5\ in$

4 in clear cover

6 in clear cover

$e = \frac{12M}{N} + d'' = \frac{12(4.76)}{2.40} + 2.5 = 26.3\ in.$

$\frac{e}{d} = \frac{26.3}{11.5} = 2.29$

$E = \frac{e}{12} = \frac{26.3}{12} = 2.19\ FT.$

$K = 152 \quad F = 0.132 \quad j = 0.891$

$NE = 2.4\ (2.19) = 5.26$

$KF = 152\ (0.132) = 20.06$

$i = 1.63$

$A_s = \frac{NE}{a\,d\,i} = \frac{5.26}{1.44(11.5)(1.63)} = 0.19\ in^2$

USE #4 @ 12

TEMP REINF.

$A_s = 12(18)(.0010) = 0.22\ in^2$

USE #5 @ 12

BY R.G.B. DATE 6 JUNE 74 SUBJECT BERNVILLE PROTECTIVE WORKS D.M. GRAVITY OUTLET AT PUMP STA

CHKD. BY G.H. DATE 6/7/74

SHEET NO. 10 OF

JOB NO. pg.6A

HEADWALL - [illegible]

SLAB ([illegible])

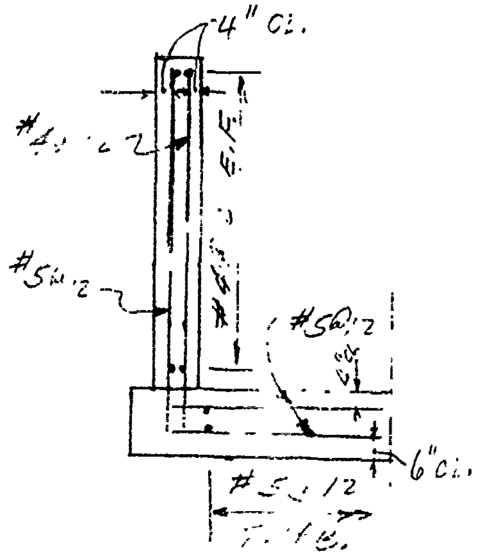
AT MIDSPAN

$$M = 4.76 - 1.09\,(9.5)\left(\tfrac{1}{2}\right)\left(\tfrac{1}{2}\right) = 2.17'K'$$

(2.59 written above)

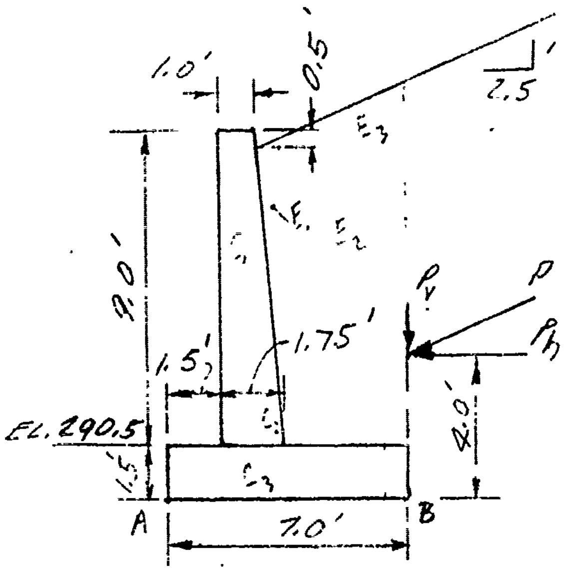
TEMP REINF. CONTROLS O.K.

USE #5 @ 12



BY R.G.B. DATE 6 JUNE 74 SUBJECT BELLVILLE SHEET NO. 11 OF ___
CHKD. BY G.H. DATE 6/10/74 PROTECTIVE WORKS D.M. JOB NO. ___
GRAVITY OUTLET AT PUMP STA
pg. 65

HEADWALL – LAND SIDE



$\gamma_{UNIT} = 125$ PCF $\phi = 22°$

ACTIVE PRESSURE COEFFICIENT REF.– E 1110-2-2502

$\beta = 90°$ THEN $i = \frac{1}{2.5} = 0.4$

$i = 21°-50' = \delta'$

$\beta = 90°$ ok.
$\beta - \phi = 90 - 22 = 68°$
$\beta + \delta = 90° + 21°50' = 111°50'$
$\phi + \delta = 22° + 21°50' = 43°-50'$
$\phi - i = 22° - 21°50' = 0°-10'$
$\beta - i = 90 - 21°50' = 68°-10'$

$$K_a = \left[\frac{CSC\,\beta\,SIN\,(\beta-\phi)}{\sqrt{SIN\,(\beta+\delta)} + \sqrt{\frac{SIN\,(\phi+\delta)\,SIN\,(\phi-i)}{SIN\,(\beta-i)}}}\right]^2$$

$$= \left[\frac{1.0\,(.927)}{\sqrt{.928} + \sqrt{\frac{.693\,(.003)}{.928}}}\right]^2$$

$K_a = 0.84$.

$P = 0.84\,(.125)(10.5)^2(\tfrac{1}{2}) = 5.79^k$

$P_h = P\cos\delta = 5.79\,(.928) = 5.37^k$

$P_v = P\sin\delta = 5.79\,(.372) = 2.15^k$

BY R.G.B. DATE 6 JUNE 74 SUBJECT BERNVILLE SHEET NO. 12 OF
CHKD. BY G.H. DATE 6/10/74 PROTECTIVE WORKS D.M. JOB NO.
GRAVITY OUTLET AT PUMP STA pg 66

HEADWALL - LANDSIDE (CONT)

STABILITY

ITEM	DESCRIPTION	$H \rightarrow$	$V \downarrow$	L.A.	M_A
C_1	1(9)(.150)		1.35	2.0	2.7
C_2	0.75(9)(.5)(.150)		0.51	2.75	1.4
C_3	1.5(7.0)(.150)		1.58	3.5	5.5
E_1	8.5(0.71)(.5)(.125)		0.38	2.97	1.1
E_2	3.75(8.5)(.125)		3.98	5.12	20.4
E_3	4.5(1.8)(.5)(.125)		0.51	5.5	2.8
P_v			2.15	7.0	15.1
P_h		-5.37		4.0	-21.5
	TOTAL	-5.37	10.46		27.5

$\bar{x} = \frac{\Sigma M}{\Sigma V} = \frac{27.5}{10.46} = 2.63' > 2.3'$ O.K. IN KERN

BASE PRESSURE

$P_A = [4(7.0) - 6(2.63)] \frac{10.46}{(7.0)^2} = 2.61$ KSF

$P_B = [6(2.63) - 2(7.0)] \frac{10.46}{(7.0)^2} = 0.38$ KSF

HEADWALL – LANDSIDE (CON'T)

REINFORCEMENT

STEM

AT EL. 290.5

$P = 0.84(.125)(8.5)^2(\frac{1}{2}) = 3.79^K$

$P_h = 3.79(.928) = 3.52^K = V$

$P_V = 3.79(.372) = 1.41^K$

$M = 3.52(.38)(8.5) = 11.37'^k$

$N = \overset{P_V}{1.41} + \overset{C_1}{1.35} + \overset{C_2}{0.51} + \overset{E_1}{0.38} = 3.65^K$

$f'_c = 3000$ psi $f_c = 0.35 f'_c = 1050$ psi $f_s = 20{,}000$

USE 4" CL. COVER

$d = 16.5$ in. $d'' = \overset{6.0}{6.5}$ in.

$e = \frac{12M}{N} + d'' = \frac{12(11.37)}{3.65} + \overset{6.0}{6.5} = 43.9$ in.^{ok} $\frac{e}{d} = \frac{43.9}{16.5} = 2.66$

$E = \frac{e}{12} = \frac{43.9}{12} = 3.66$ FT.

$K = 152$ $j = 0.891$
$F = .272$

$NE = 3.65(3.66) = 13.36$
$KF = 152(.272) = 41.34$

$i' = 1.50$

$A_s = \frac{NE}{adi'} = \frac{13.36}{1.44(16.5)(1.50)} = 0.37$ in^2

USE #6 @ 12

$v = \frac{V}{bd} = \frac{3520}{12(16.5)} = 18$ psi < 60 psi O.K.

BY R.G.B. DATE 6 JUNE 74 SUBJECT BERNVILLE PROTECTIVE WORKS D.M. GRAVITY OUTLET AT PUMP STA SHEET NO. 14 OF JOB NO.

CHKD. BY DATE

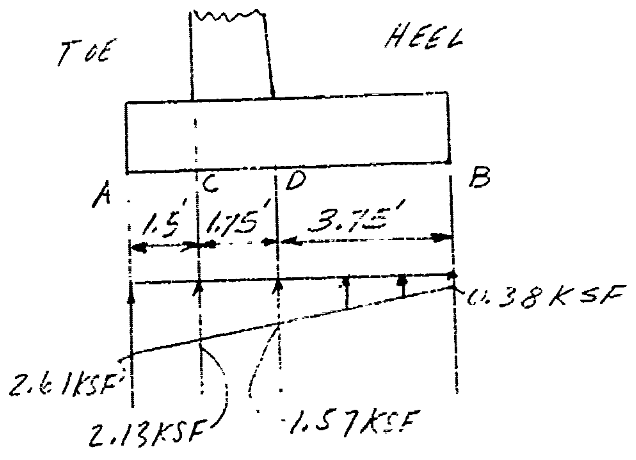
HEADWALL - LANDSIDE (CONT)

REINF. (CONT)

STEM (CONT)

$L_d = 13$ in.

FOOTING



$$P_C = (2.61 - 0.38)\frac{5.5}{7.0} + 0.38 = 2.13 \text{ KSF}$$

$$P_D = (2.61 - 0.38)\frac{3.75}{7.0} + 0.38 = 1.57 \text{ KSF}$$

HEEL

$$M_D = 0.38(3.75)^2\left(\tfrac{1}{2}\right) + (1.57 - 0.38)(3.75)^2\left(\tfrac{1}{2}\right)\left(\tfrac{1}{3}\right) - \left(8.5 + \tfrac{1.8}{2}\right)(.125)\left(\tfrac{3.75}{2}\right)^2 - 1.5(.150)\left(3.75\right)^2\left(\tfrac{1}{2}\right)$$

2.67 2.79 8.26 1.58

$M_D = 4.38$'K.

BY R.G.B. DATE 7 JUNE 74 SUBJECT BELLVILLE PROTECTIVE WORKS ... GRAVITY OUTLET AT PUMP STA

CHKD. BY J.H. DATE 6/10/74

SHEET NO. 15 OF ...

JOB NO. ...

pg. 109

HEADWALL - LANDSIDE (CONT)

REINF. (CONT)

HEEL (CONT)

$V_0 = 0.38(3.75) + (1.57 - 0.38)(3.75)(\frac{1}{2}) - 1.5(.150)(3.75) - (8.54 + \frac{...}{2})(.125)(3.75)$

$V_0 = 1.59^{K}$

$f'_c = 3000$ $f_c = 0.35\ f'_c = 1050\ psi$

4" CL. COVER TOP

6" CL. COVER BOTTOM

$d = 13.5\ in.$

$K = 152$ $F = .182$

$M = 4.38$

$KF = 152(.182) = 27.66$

$A_s = \frac{M}{ad} = \frac{4.38}{1.44(13.5)} = 0.23\ in^2$

USE #5 @ 12 TOP.

$v = \frac{V}{bd} = \frac{1590}{12(13.5)} = 10\ psi < 60\ psi\ O.K.$

$L_d = 10(1.4) = 14\ in$

TOE

$M_c = 2.13\left(\frac{1.5}{2}\right)^2 + (2.61 - 2.13)(1.5)^2(\frac{1}{2})(\frac{2}{3}) - 1.5(.150)\frac{(1.5)^2}{2}$

$M_c = 2.51'K$

TEMP REINF CONTROLS

$A_s = 12(18)(.001) = 0.22\ in^2$

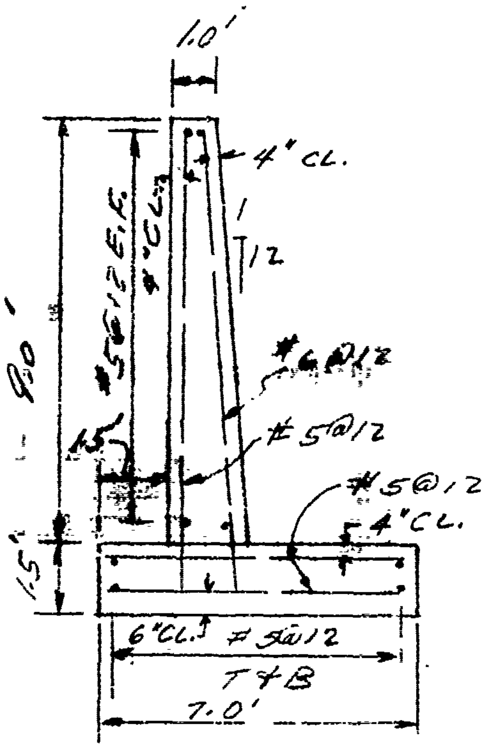
USE #5 @ 12

BY R. G. B. DATE 7 JUNE 74 SUBJECT BERNVILLE SHEET NO. 16 OF

CHKD. BY G.H. DATE 6/13/74 PROTECTIVE WORK: D.M. JOB NO.

GRAVITY OUTLET AT PUMP STA pg. 10

HEADWALL - LANDSIDE (CONT.)



DESIGN CRITERIA

REFERENCES:

1) EM 1110-2-2501
2) EM 1110-2-2502
3) EM 1110-1-2101
4) EM 1110-2-2103
5) ACI 318-71

SOIL DATA:

$\gamma_{NAT} = 125$ PCF
$\gamma_{SAT} = 135$ PCF
$\gamma_{SUB} = 72.5$ PCF

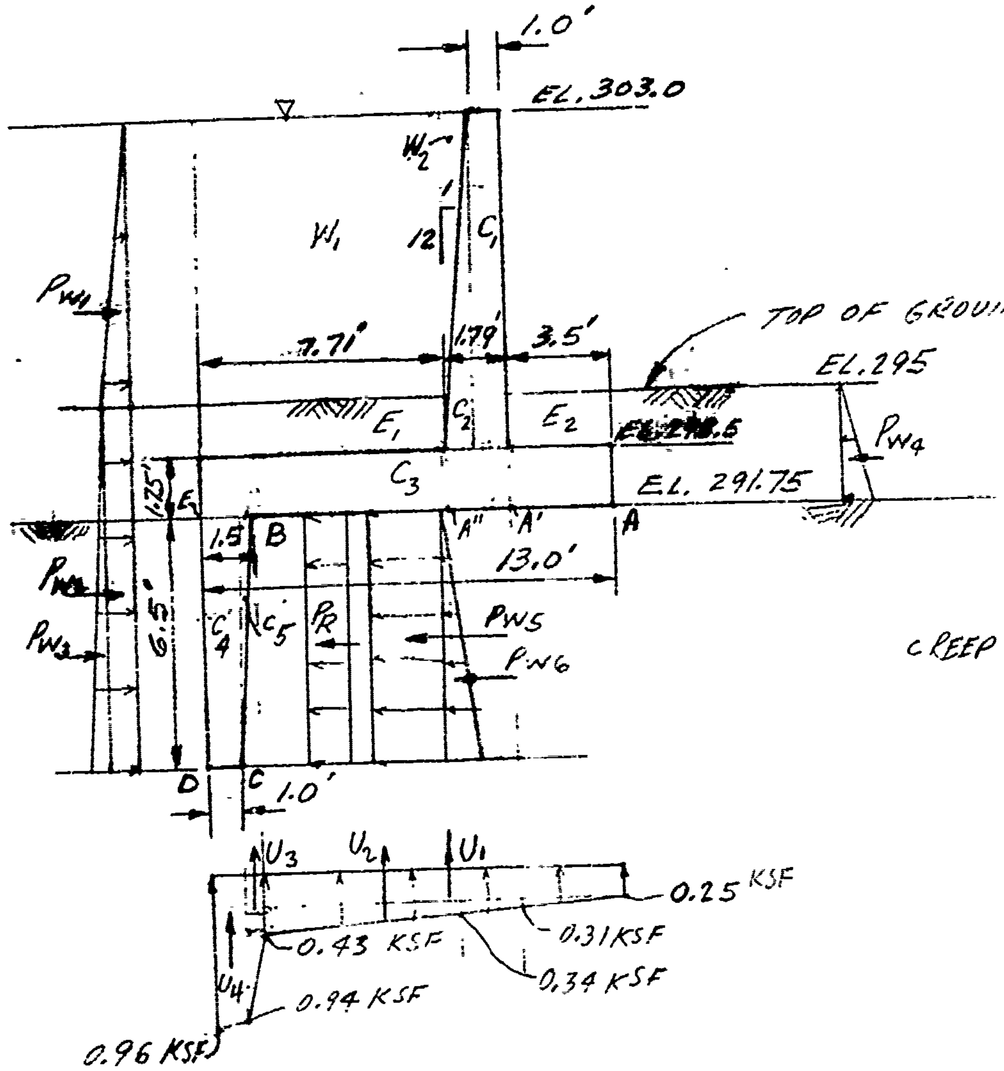
BY R.G.B. DATE 27AUG74 SUBJECT BERNVILLE PROTECTIVE WORKS D.M. FLOOD WALL AT SEWAGE PLANT

CHKD. BY G.H. DATE 30Aug 74

SHEET NO. 2 OF

JOB NO.

STABILITY



CREEP RATIO = $\frac{32.0}{8}$ = 4.0 O.K.

$P_{A'} = \left[6.75\frac{(8)}{32} + 3.25\right]0.0625 = 0.31$ KSF.

$P_{A''} = \left[8.54\frac{(8)}{32} + 3.25\right]0.0625 = 0.34$ KSF.

$P_{A} = \left[3.25\frac{(8)}{32} + 3.25\right]0.0625 = 0.25$ KSF

$P_{B} = \left[14.75\frac{(8)}{32} + 3.25\right]0.0625 = 0.43$ KSF

$P_{C} = \left[21.25\frac{(8)}{32} + 9.75\right]0.0625 = 0.94$ KSF.

$P_{D} = \left[22.25\frac{(8)}{32} + 9.75\right]0.0625 = 0.96$ KSF.

$P_{E} = \left[28.75\frac{(8)}{32} + 3.25\right]0.0625 = 0.65$ KSF.

BY R.G.B. DATE 28 AUG 74 SUBJECT BERLINVILLE SHEET NO. 3 OF
CHKD. BY G.L. DATE 30 Aug 74 PROTECTIVE WORKS D.M. JOB NO.
FLOOD WALL AT SEWAGE PLANT pg. 13

STABILITY (CONT)

ITEM	DESCRIPTION	H →	V ↓	L.A.	M_A ↻
C_1	1.0(9.5)(.150)		1.43	4.0	5.70
C_2	0.79(9.5)(.5)(.150)		0.56	4.76	2.68
C_3	13.0(1.75)(.150)		3.41	6.5	22.18
C_4	1.0(6.5)(.150)		0.98	12.5	12.19
C_5	0.5(6.5)(0.5)(.150)		0.24	11.83	2.88
	SUB-TOTAL 1		6.62		45.63
W_1	7.71(9.5)(.0625)		4.58	9.15	41.89
W_2	0.79(9.5)(.5)(.0625)		0.23	5.03	1.16
	SUB-TOTAL 2		4.81		43.05
E_1	1.5(7.71)(.0725)		0.84	9.15	7.67
E_2	1.5(3.5)(.135)		0.71	1.75	1.24
	SUB-TOTAL 3		1.55		8.91
P_{W_1}	$(8)^2(.0625)(\frac{1}{2})$	-2.00		5.92	-11.84
P_{W_2}	8(.0625)(9.75)	-4.88		-1.63	7.95
P_{W_3}	[0.96-8(.0625)](9.75)($\frac{1}{2}$)	-2.24		-3.25	7.29
P_{W_4}	0.25(3.25)($\frac{1}{2}$)	0.41		1.08	0.44
P_{W_5}	0.43(6.5)	2.80		-3.25	-9.08
P_{W_6}	(0.94-0.43)(6.5)($\frac{1}{2}$)	1.66		-4.33	-7.18
	SUB-TOTAL 4	-4.25			-12.42
U_1	0.25(11.5)		-2.88	5.75	-16.53
U_2	(0.43-0.25)(11.5)(0.5)		-1.04	7.67	-7.94
U_3	$(0.43+0.94)(0.5)^2$		-0.34	11.75	-4.02
U_4	0.95(1)		-0.95	12.50	-11.88
	SUB-TOTAL 5		-5.21		-40.37
P_R		4.25		-3.25	-13.81
	TOTAL		7.77		30.99

BY R.G.B. DATE 28 AUG 74 SUBJECT BERNVILLE
PROTECTIVE WORKS D.M.
FLOOD WALL AT SEWAGE PLANT
CHKD. BY G.H. DATE 30 Aug 74

STABILITY (CONT)

$$\bar{X} = \frac{\Sigma M_A}{\Sigma V} = \frac{30.99}{7.77} = 3.99' \quad O.K.$$

BASE PRESS.

$$P_A = \frac{2(7.77)}{3(3.99)} = 1.30 \text{ KSF}$$

REINF. $f'_c = 3000$ psi $\quad f_c = 0.35 f'_c = 1050$ psi

STEM $\quad f_s = 20{,}000$ psi

AT EL. 293.5

$$M = (9.5)^3(.0625)\left(\tfrac{1}{2}\right)\left(\tfrac{1}{3}\right) = 8.93'K$$

$$V = (9.5)^2(.0625)\left(\tfrac{1}{2}\right) = 2.82K$$

$K = 152 \quad F = .289 \qquad d = 17.0$ in

$d' = 4.5$ in

$KF = 152(.289) = 43.9$

$$A_s = \frac{M}{ad} = \frac{8.93}{1.44(17.0)} = 0.36 \text{ in}^2$$

USE #6 @ 12 WATER ... 4 in. COVER

$$v = \frac{V}{bd} = \frac{2820}{12(17.0)} = 14 \text{ psi} < 6 \ldots \quad O.K.$$

$L_d = 13$ in.

TEMP. REINF.

$A_s = 0.001(12)(21.5) = 0.26$ in^2

USE # ... 12

BY R.G.B. DATE 29 AUG 74 SUBJECT BERNVILLE SHEET NO. 5 OF
CHKD. BY G.H. DATE 30 Aug 74 PROTECTIVE WORKS D.M. JOB NO.
FLOOD WALL AT SEWAGE PLANT pg. 75

REINF. (CONT)

KEY

AT EL. 291.75

$$M = 4.25(3.25)' + 2.80(3.25)' + 1.66(4.33)' - 0.65\left(\frac{6.5}{2}\right)^2 - (0.96-0.65)\left(\frac{6.5}{2}\right)^2\left(\frac{2}{3}\right)$$

$M = 12.0'K$

$V = 4.25 + 2.80 + 1.66 - 0.65(6.5) - (0.96-0.65)\left(\frac{6.5}{2}\right)$

$V = 3.22^K$ 3.48

$d = 13.5$ in.

$K = 152$ $F = .182$

$KF = 152(.182) = 27.7$

$$A_s = \frac{M}{ad} = \frac{12.0}{1.44(13.5)} = 0.62 \text{ in}^2$$

USE #8 @ 12'' LANDSIDE FACE 4in. COVER

$$v = \frac{V}{bd} = \frac{3220}{12(13.5)} = 20 \text{ PSI} < 60 \text{ PSI O.K.}$$

(3480 written above 3220; 21 written above 20)

$L_d = 23$ in.

HOOK REQ'D.

$f_h = \xi \sqrt{f'_c} = 360\sqrt{3000} = 19,718$

$L_e = 0.04 A_b f_h / \sqrt{f'_c} = 0.04(0.79)(19,718)/\sqrt{3000}$

$L_e = 11$ in.

USE 12 in + HOOK

TEMP. REINF.

$A_s = 0.001(12)(18) = 0.22 \text{ in}^2$

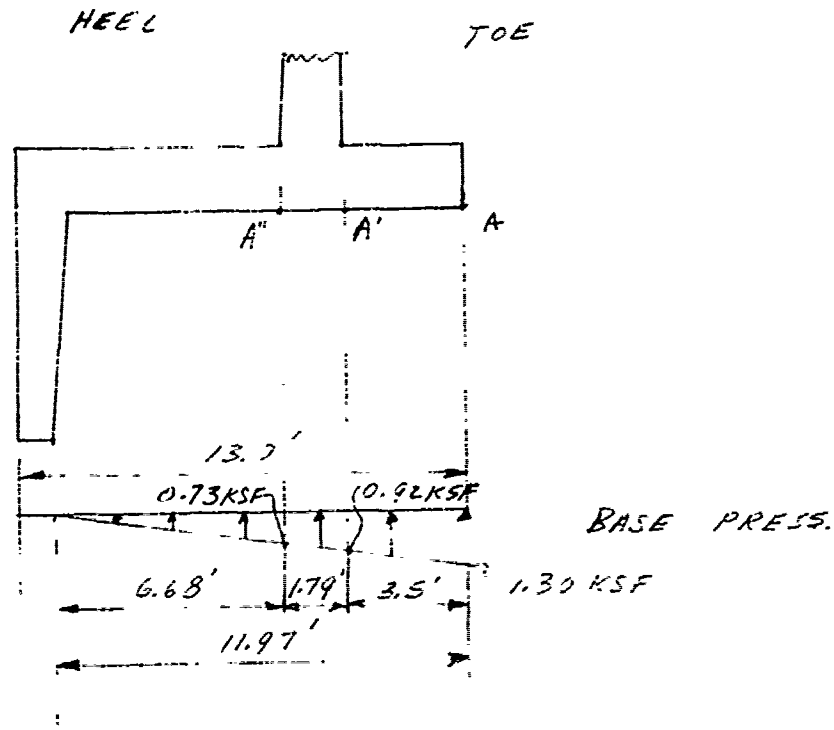
USE #5 @ 12''

BY R.G.B. DATE 29 AUG 74 SUBJECT BERNVILLE SHEET NO. 6 OF

CHKD. BY G.H. DATE 9/4/74 PROTECTIVE WORKS D.M. JOB NO.

FLOOD WALL AT SEWAGE PLANT pg. 76

REINF. (CONT)



$$P_{A''} = 1.30\left(\frac{6.68}{11.97}\right) = 0.73 \text{ KSF}$$

$$P_{A'} = 1.30\left(\frac{8.47}{11.97}\right) = 0.92 \text{ KSF}$$

TOE

$$M_{A'} = 0.92(3.5)^2\left(\tfrac{1}{2}\right) + (1.30-0.92)(3.5)^2\left(\tfrac{1}{2}\right)\left(\tfrac{2}{3}\right)$$
$$- 1.5(.135)(3.5)^2\left(\tfrac{1}{2}\right) - 1.75(.150)(3.5)^2\left(\tfrac{1}{2}\right)$$
$$+ 0.25(3.5)^2\left(\tfrac{1}{2}\right) + (0.31-0.25)(3.5)^2\left(\tfrac{1}{2}\right)\left(\tfrac{2}{3}\right)$$

$M_{A'} = 6.11'K$

$$V_{A'} = 0.92(3.5) + (1.30-0.92)(3.5)\left(\tfrac{1}{2}\right) - 1.5(.135)(3.5)$$
$$-1.75(.150)(3.5) + .25(3.5) + (0.31-0.25)(3.5)\left(\tfrac{1}{2}\right)$$

$V_{A'} = 3.25K$

BY R.G.B. DATE 29 AUG 74 SUBJECT BERNVILLE
CHKD. BY G.H. DATE 9/4/74 PROTECTIVE WORKS D.M.
FLOOD WALL AT SEWAGE PLANT

SHEET NO. 7 OF
JOB NO.
pg. 77

REINF. (CONT)

TOE (CONT.)

$d = 14.5$ in.

$K = 152$ $\quad F = 0.210$

$KF = 152\ (0.210) = 31.92$

$$A_s = \frac{M}{ad} = \frac{6.11}{1.44(14.5)} = 0.29 \text{ in}^2$$

USE #5 @ 12 BOTTOM FACE 6 in. COVER

$$v = \frac{V}{bd} = \frac{3250}{12(14.5)} = 19 \text{ PSI} < 60 \text{ PSI O.K.}$$

$L_d = 12$ in.

BY R.G.B. DATE 29AUG74 SUBJECT BERNVILLE
CHKD. BY G.H. DATE 9/4/74 PROTECTIVE WORKS D.M.
FLOOD WALL AT SEWAGE PLANT

SHEET NO. 8 OF
JOB NO.
pg. 78

REINF. (CONT)

HEEL

$$M_{A''} = 9.5(.0625)\left(\frac{7.71^2}{2}\right) + 1.5(.0725)\left(\frac{7.71^2}{2}\right) - 0.95(7.21)$$
$$- 0.34(6.46) - 0.34\left(\frac{6.21^2}{2}\right) - (0.43-0.34)(6.21)^2\left(\tfrac{1}{2}\right)\left(\tfrac{2}{3}\right)$$
$$-12.0 - \overset{3.48}{3.22}\left(\frac{1.75}{2}\right) - 0.73(6.68)^2\left(\tfrac{1}{2}\right)\left(\tfrac{1}{3}\right)$$

$$M_{A''} = \overset{16.35}{-16.14}\ 'K$$

$$V_{A''} = 9.5(.0625)(7.71) + 1.5(.0725)(7.71) - 0.95 - 0.34$$
$$- 0.34(6.21) - (0.43-0.34)(6.21)\left(\tfrac{1}{2}\right) - 0.73(6.68)\left(\tfrac{1}{2}\right)$$

$$V_{A''} = -0.70^K$$

$d = 14.5$ in.

$K = 152$ $F = 0.210$

$KF = 152(0.210) = 31.92$

$$A_s = \frac{M}{ad} = \frac{\overset{16.35}{16.14}}{1.44(14.5)} = \overset{0.78}{0.77}\ in^2$$

USE #8@12 BOTT. [illegible] 6 in. COVER

$$v = \frac{V}{bd} = \frac{700}{12(14.5)} = 4\ psi < 60\ psi\ O.K.$$

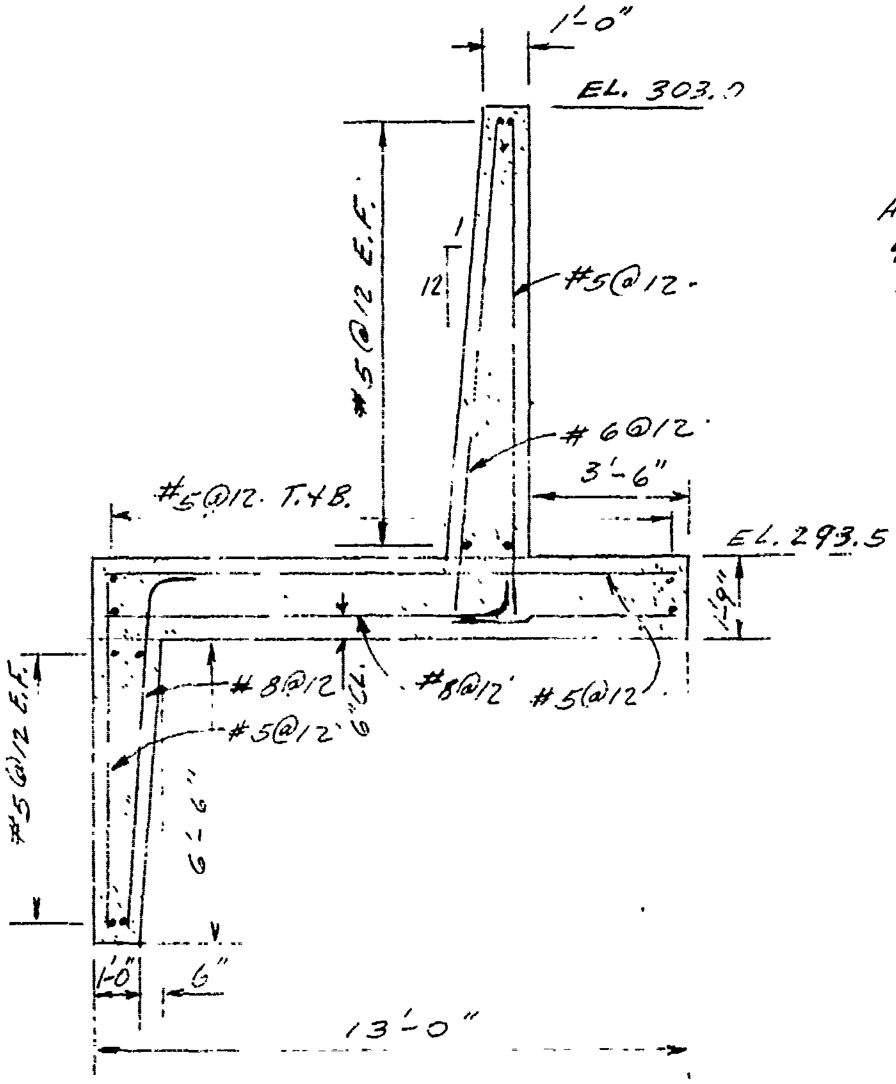
$L_d = 23$ in. USE HOOK

TEMP REINF.

$A_s = 0.001(12)(21) = 0.25\ in^2$

USE #5@12

BY R.G.R. DATE 29AUG74 SUBJECT BERNVILLE SHEET NO. 9 OF
CHKD. BY S.H. DATE 9/4/74 PROTECTIVE WORKS D.M. JOB NO.
FLOOD WALL AT SEWAGE PLANT pg. 79



ALL REINF.
4" CL. COVER
EXCEPT AS
NOTED

BY R.G.B. DATE 30 APR 74 SUBJECT BIENVILLE SHEET NO. 1 OF
CHKD. BY G.H. DATE 6/10/74 PROTECTIVE WORKS D.M. JOB NO.
QUANTITIES - PRELIM. pg. 80

BOX CULVERT

EXCAVATION, COMMON

STA.	AREA	AVE. AREA	DIST.	VOL.
0+79	357			
		368	76	27,968
1+55 BK	379			
		—	—	—
1+55 AH	201			
		249	45	11,205
2+00	297			
		391	100	39,100
3+00	485			
		644	100	64,400
4+00	802			
		802	100	80,200
5+00	802			
		642	122	78,263
6+22	481			
		—	—	—
1+55 A	178			
		112	45	5018
2+00 A	45			
		65	62	4030
2+62 A	85			
			TOTAL	310,184 C.F. = 11,488 C.Y.

BY R.G.B. DATE 1 MAY 74 SUBJECT BERNVILLE SHEET NO. 2 OF
CHKD. BY G.H. DATE 6/10/74 PROTECTIVE WORKS D.M. JOB NO.
QUANTITIES - PRELIM. pg. 81

BOX CULVERT (CONT)

BACKFILL, RANDOM

STA.	AREA	AVE. AREA	DIST.	VOL.
0+79	222'			
		235	76	17,860'
1+55 BK	248'			
		–	–	–
1+55 AH	128'			
		184	45	8258'
2+00	239'			
		337	100	33,700
3+00	435'			
		600	100	60,000
4+00	765'			
		765	100	76,500
5+00	764'			
		598	122	72,895
6+22	431'			
		–	–	–
1+55 A	120'			
		129	45	5783
2+00 A	137'			
		132	62	8184
2+62 A	127'			
			TOTAL	283,180 C.F. = 10,488 C.Y.

BY R.G.B. DATE 30 MAY 74 SUBJECT BERNVILLE SHEET NO. 2A OF

CHKD. BY G.H. DATE 6/10/74 PROTECTIVE WORKS D.M. JOB NO.

QUANTITIES - PRELIM. pg. 92

BOX CULVERT

STRIPPING

STA.	AREA	AVE. AREA	DIST.	VOL.
0+79	45			
		47	76	3572
1+55 BK	49			
		–	–	–
1+55 AH	25			
		33	45	1485
2+00	40			
		44	100	4400
3+00	48			
		55	100	5500
4+00	61			
		61	100	6100
5+00	60			
		54	122	6588
6+22	48			
		–	–	–
1+55A	24			
		29	45	1305
2+00A	34			
		31	62	1922
2+62A	28			
				30,872 C.F. = 1143 C.Y.

BOX CULVERT (CONT)

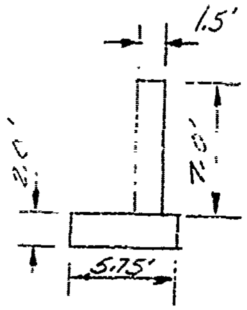
CONCRETE

BOXES

[1.17(12) + 1(12) + 1(5)(2)]530 + [0.83(11) + 1(11) + 1(6)(2)]193

= 26,3~~55~~ 62 C.F.

WINGWALLS



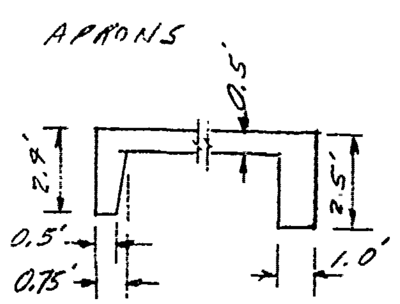
A = 7(1.5) + 2(5.75) = 22.0 S.F.

FOR LOW END
SEE PIPE ARCH

A = 19.5 S.F.

(22.0 + 19.5)(0.5)(28 + 12 + 34 + 18 + 20 + 20) = 2739 C.F.

APRONS



0.5[(58)(10) + 20(1.7) + 10(30)] = 610 C.F.
1(2.0)(73 + 45 + 30) = 296 C.F.
1.9(0.5 + 0.75)(.5)[50 + 16 + 10] = 90 C.F.

TOTAL 30,095 C.F.
= 1114 C.Y.

BY R.G.B. DATE 1MAY74 SUBJECT BERNVILLE
CHKD. BY G.H. DATE 6/11/74 PROTECTIVE WORKS D.M.
QUANTITIES — PRELIM.

SHEET NO. 4 OF
JOB NO.
pg.39

BOX CULVERT (CONT)

CEMENT

1114 (5.5)(.94) = 5758 CWT

REINFORCEMENT

BOXES

[250(530) + 157(170)] 1/2000 = 79.6 TON

W.. + WALLS

$\frac{2739(10)}{27(2000)}$ = 0.5

TOTAL 80.1 TON

BY R.G.B. DATE 25 APR 74 SUBJECT BELNVILLE SHEET NO. 1 OF

CHKD. BY G.H. DATE 6/11/74 PROTECTIVE WORKS D.M. JOB NO.

QUANTITIES - PRELIM.

PIPE ARCH CULVERT

12'-4" X 7'-9" PIPE ARCH

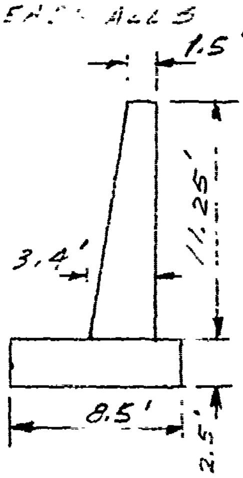
12 GAGE
PAVED INVERT 196 L.F.

16'-5" X 9'-11" PIPE ARCH

10 GAGE
PAVED INVERT 503 L.F.

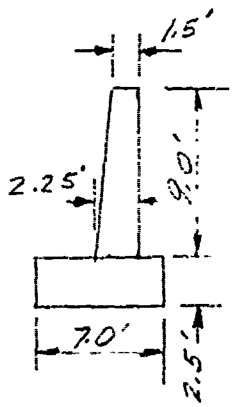
CONCRETE
REF:- PEI ?ROT BD-131

HEADWALLS



$$[8.5(2.5) + (3.4+1.5)(.5)(11.25)](28+98)$$
$$-2.5(126+70+126)$$

$$= 6150 - 815 \qquad = 5335 \text{ C.F.}$$



$$[9(1.5+2.25)(.5)+2.5(7.0)](14)$$
$$-2(?4) = 482 - 143 = 33[illegible] \text{ C.F.}$$

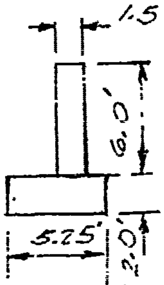
BY R.G.B. DATE 25APR74 SUBJECT BERNVILLE
CHKD. BY G.D DATE 6/11/74 PROTECTIVE WORKS D.M.
QUANTITIES - PRELIM.

SHEET NO. 2 OF
JOB NO.
PG 86

PIPE ARCH CULVERT

CONCRETE (CONT)

WINGWALLS



$A = \overset{10.5}{5.25(2)} + 6.0\overset{9}{(1.5)} = 19.5$ S.F.

$(48.8 + 19.5)(0.5)(36 + 17 + 66 + 24) = 4883$ C.F.

$(34.4 + 19.5)(0.5)(18)(2) = 970$ C.F.

TOTAL 11,522 C.F.

= 427 C.Y.

REINFORCEMENT

$427 \frac{(50)}{2000} = 10.7$ TON

CEMENT

$428(5.5)(.94) = 2213$ CWT

BY R.G.B. DATE 29 MAY 74 SUBJECT BERNVILLE SHEET NO. 3 OF
CHKD. BY G.H. DATE 6/11/74 PROTECTIVE WORKS D.M. JOB NO.
QUANTITIES – PRELIM. pg.87

PIPE ARCH CULVERT

EXCAVATION, COMMON

STA.	AREA	AVE. AREA	DIST.	VOL.
0+00	451.			
		483.	80.	38,600.
1+70 BK	514.			
		—	—	—
1+70 AH	287.			
		325.	30.	9735.
2+00	362.			
		459.	100	45,900.
3+00	556.			
		728.	100	72,800
4+00	899.			
		899.	100.	89,900
5+00	899.			
		714.	118	84,252
6+18	529.			
		—	—	—
1+70 A	227.			
		136	30	4080.
2+00 A	45.			
		62	57	3534.
2+57A	79			
			TOTAL	348,801 C.F. = 12,919 C.Y.

BY R.G.B. DATE 29 MAY 74 SUBJECT BERLIVILLE — SHEET NO. 4 OF

CHKD. BY G.H. DATE 6/11/74 — PROTECTIVE WORKS D.M. — JOB NO.

QUANTITIES – PRELIM. — pg. 8a

PIPE ARCH CULVERT

STRIPPING

STA.	AREA	AVE. AREA	DIST.	VOL.
0+90	66.			
		62	80.	4920.
1+70 BK	[illegible].			
		—	—	—
1+70 AH	31.			
		38	30.	1125 -
2+00	44.			
		48	100.	4800.
3+00	52.			
		59	100	5900.
4+00	65.			
		65.	100	6500.
5+00	65.			
		58	118.	6844.
[illegible] 7	51.			
		—	—	—
1+70 A	26.			
		31.	30	930.
2+00A	36.			
		32.	57.	1824.
2+57A	28.			
			TOTAL	32,843 C.F. = 1216 C.Y.

BY R.G.B. DATE 29/10/74 SUBJECT BERLIN[illegible] SHEET NO. 5 OF
CHKD. BY G.H. DATE 6/11/74 PROTECTIVE WORKS D.M. JOB NO.
QUANTITIES – PRELIM. P3.89

PIPE ARCH CULVERT

BACKFILL, GRANULAR

STA.	AREA	AVE. AREA	DIST.	VOL.
0+00	99.			
		98.	80	784.
1+70 BK	[illegible]			
		—	—	—
1+70 AH	54.			
		64.	30	1920.
2+00	74.			
		74.	100	7400.
3+00	74.			
		74	100	7400.
4+00	74.			
		74	100	7400.
5+00	74.			
		74.	118	8732.
6+18	74.			
		—	—	—
1+70 A	43.			
		49.	30	1470.
2+00 A	54.			
		54.	57	3078.
2+57 A	54.			
			TOTAL	38,184 C.F. = 1414 C.Y.

BY R.S.B. DATE 29 MAY 74 SUBJECT BERNVILLE PROTECTIVE WORKS D.M. QUANTITIES - PRELIM. SHEET NO. 6 OF

CHKD. BY GR DATE 6/11/74 JOB NO. pg. 90

PIPE ARCH CULVERT

BACKFILL, RANDOM

STA.	AREA	AVE. AREA	DIST.	VOL.
0+00	208.			
		240.	80	19,200.
1+70 BK	272.			
		—	—	—
1+70 AH	123.			
		173.	30	5190.
2+00	207.			
		311.	100	31,100.
3+00	414.			
		589.	100	58,900.
4+00	763.			
		767.	100	76,700.
5+00	770.			
		577.	118.	68,086.
6+15	384.			
		—	—	—
1+70 A	133.			
		116.	30.	3465.
2+00 A	98.			
		98.	57.	5586.
2+57 A	98.			
			TOTAL	268,227 C.F. = 9934 C.Y. ✓

SHEET NO. ____ OF ____

CHKD. BY G.H. DATE 6/10/74

SUBJECT PROTECTIVE WORKS D.M.
QUANTITIE - PRELIM.

JOB NO. pg 91

DOUBLE PIPE ARCH CULVERT

9'-4" x 6'-3" PIPE ARCH

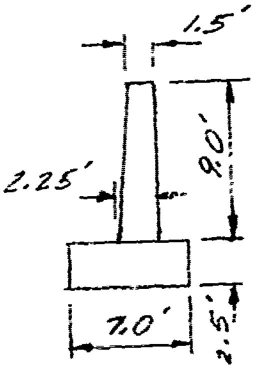
12 GAGE — 1115 L.F.
PAVED INVERT

11'-10" x 7'-7" PIPE ARCH

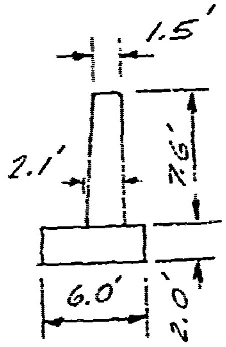
12 GAGE — 240 L.F.
PAVED INVERT

CONCRETE

HEADWALLS

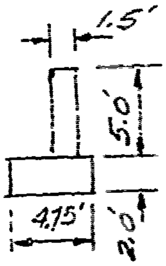


$$\left[9(1.5+2.25)(.5)+2.5(7)\right](12.6+12)$$
$$-\left[2(71)+2(46)\right]2 = 4747-468$$
$$= 4279 \text{ C.F.}$$



$$\left[7.6(1.5+2.1)(.5)+2(6)\right]47 - 1.8(46)(2)$$
$$= 1041 \text{ C.F.}$$

WINGWALLS



$$A = 5(1.5)+2(4.75) = 17.0 \text{ S.F.}$$

$$(17+25.7)(.5)(32+10) + (17+34.4)(.5)(46+7+16+16)$$
$$= 3210 \text{ C.F.}$$

TOTAL 8530 C.F.
= 316 C.Y.

BY R.G.B. DATE 16 MAY 74 SUBJECT BERNVILLE SHEET NO. 2 OF

CHKD. BY G.H. DATE 6/10/74 PROTECTIVE WORKS D.M. JOB NO.

QUANTITIES - PRELIM. pg. 92

DOUBLE PIPE ARCH CULVERT

REINFORCEMENT

$\frac{316(50)}{2000}$ = 7.9 TON'

CEMENT

316 (5.5)(.94) = 1634 CWT.

BY R.G.B. DATE 4 JUNE 74 SUBJECT BERNVILLE SHEET NO. 3 OF

CHKD. BY G.H. DATE 6/10/74 PROTECTIVE WORKS D.M. JOB NO.

QUANTITIES - PRELIM. pg. 93

DOUBLE PIPE ARCH CULVERT

STRIPPING

STA.	AREA	AVE. AREA	DIST.	VOL.
0+53	58			
		59	47	2773
1+00	60			
		61	70	4270
1+70 BK	61			
		—	—	—
1+70 AH	37			
		42	30	1260
2+00	47			
		52	100	5200
3+00	57			
		64	100	6400
4+00	70			
		70	100	7000
5+00	70			
		63	100	6300
6+00	56			
		53	30	1590
6+30	50			
		—	—	—
1+70A	24			
		29	30	870
2+00A	33			
		30	46	1380
2+46A	27			
			TOTAL	37,043 C.F. = 1,372 C.Y.

BY R.G.B. DATE 4 JUNE 74 SUBJECT BERNVILLE SHEET NO. 4 OF
CHKD. BY GH DATE 6/10/74 PROTECTIVE WORKS DM. JOB NO.
QUANTITIES - PRELIM. pg. 94

DOUBLE PIPE ARCH CULVERT

EXCAVATION, COMMON

STA.	AREA	AVE. AREA	DIST.	VOL.
0+53	401			
		458	47	21,526
1+00	515			
		516	70	36,120
1+70 BK	517			
		—	—	—
1+70 AH	347			
		366	30	10,980
2+00	385			
		509	100	50,900
3+00	632			
		806	100	80,600
4+00	980			
		987	100	98,700
5+00	994			
		802	100	80,200
6+00	610			
		464	30	13,905
6+30	317			
		—	—	—
1+70 A	170			
		103	30	3075
2+00 A	35			
		58	46	2645
2+46 A	80			
			TOTAL	398,651 C.F. = 14,765 C.Y.

BY R.G.B. DATE 4 JUNE 74 SUBJECT BERNVILLE SHEET NO. 5 OF

CHKD. BY [illegible] DATE 6/10/74 PROTECTIVE WORKS D.M. JOB NO.

QUANTITIES - PRELIM. pg. 95

DOUBLE PIPE ARCH CULVERT

BACKFILL, GRANULAR

STA.	AREA	AVE. AREA	DIST.	VOL.
0+53	95			
		103	47	4818 ok.
1+00	110			
		105	70	7350
1+70 BK	100			
		—	—	—
1+70 AH	63			
		69	30	2070
2+00	74			
		74	100	7400
3+00	74			
		74	100	7400
4+00	74			
		74	100	7400
5+00	74			
		74	100	7400
6+00	74			
		74	30	2220
6+30	74			
		—	—	—
1+70A	37			
		44	30	1320
2+00A	50			
		50	46	2300
2+45A	50			
			TOTAL	49,678 C.F. = 1840 C.Y.

BY R.G.B. DATE 4 JUNE 74 SUBJECT BERNVILLE SHEET NO. 6 OF
CHKD. BY G.H. DATE 6/10/74 PROTECTIVE WORKS D.M. JOB NO.
QUANTITIES - PRELIM. pg. 96

DOUBLE PIPE ARCH CULVERT

BACKFILL, RANDOM

STA.	AREA	AVE. AREA	DIST.	VOL.
0+53	207			
		260	47	12,197
1+00	310			
		317	70	22,190
1+70 BK	324			
		—	—	—
1+70 AH	231			
		250	30	7485
2+00	268			
		396	100	39,600
3+00	523			
		712	100	71,200
4+00	901			
		905	100	90,500
5+00	908			
		707	100	70,700
6+00	505			
		361	30	10,830
6+30	216			
		—	—	—
1+70A	93			
		97	30	2895
2+00A	100			
		99	46	4531
2+46	97			
			TOTAL	332,128 C.F. = 12,301 C.Y.

COST COMPARISON

UPPER DRAINAGE STRUCTURE

6/11/74

Pipe Arch Culvert

12'-4" x 7'-9"	196 LF	120	23,520
16'-5" x 9'-11"	503 LF	150	75,450
Concrete	427 CY	175	74,725
Re-Bar	10.7 Ton	800	8,560
Cement	2213 CWT	3.50	7,746
Common Exc.	12,919 CY	1.50	19,379
Stripping	1,216 CY	1.75	2,128
Granular Bkfl.	1,414 CY	3.00	4,242
Random Bkfl.	9,934 CY.	2.50	24,835

Cost includes OH & Profit but no Contingencies 240,585

RW 6/11/74
[illegible] 6/11/74

6/11/74

Double Pipe Arch Culvert

9'-4" x 6'-8" Pipe Arch	1115 LF	100	111,500
11'-10" x 7'-7" " "	240 LF	118	28,320
Concrete	316 CY	175	55,300
Re-Bar	7.9 Ton	800	6,320
Cement	1634 CWT	3.50	5,719
Stripping	1372 CY	1.75	2,401
Common Exc.	14,765 CY	1.50	22,148
Granular Bkfl.	1,840 CY	3.00	5,520
Random Bkfl	12,301 CY	2.50	30,753

Cost includes OH & Profit but no Contingencies $267,781

R. W. 6/11/74
[illegible] 6/11/74

6/11/74

BOX CULVERT

COMMON EXC.	11,488 CY	1.50	17,232
RANDOM BKFL.	10,488 CY	2.50	26,220
STRIPPING	1,143 CY	1.75	2,000
CONCRETE	1,114 CY	175	194,950
REBAR	80.1 TON	800	64,080
CEMENT	5758 CWT	3.50	20,153

COST INCLUDES OH & PROFIT BUT NO CONTINGENCIES 324,635

RW 6/11/74

[illegible]

BY .... DATE .... SUBJECT Bernville Local Protection Pump Station SHEET NO. .... OF ......
CHKD. BY .... DATE .... MECHANICAL CALCULATIONS JOB NO. ....

Computations were made using model curves from EM 1110-2-3105. A summary of the calculations is tabulated below.

Constant head comparison:

	Model Curve	Pump Size	Capacity gpm	BHP	RPM	Submerg. feet
1.	21A	60"	103500	1240	360	+2
2.	21B	60"	103500	1200	360	+3
3.	21C	60"	110000	1220	400	+8
4.	18 (2 stage)	60"	109500	1200	360	+3
5.	21A	60"	88500	1010	360	+1
6.	21B	60"	98500	1130	360	+3
7.	21C	60"	94500	1000	400	+5
8.	19 (2 stage)	60"	97000	1060	360	+1
9.	21A	60"	104000	1160	360	+3
10.	21C	60"	93500	980	400	+5
11.	20 (2 stage)	60"	110000	1260	360	+2
12.	20 (2 stage)	60"	100500	1160	360	+3
13.	20 (2 stage)	48"	101000	1250	450	+13
14.	20 (2 stage)	48"	90500	1070	450	+10
15.	19 (2 stage)	54"	96000	1100	400	+5
16.	19 (2 stage)	54"	86500	975	400	+3
17.	19 (2 stage)	54"	89400	1020	400	-4
18.	18 (2 stage)	54"	89000	990	360	-1 (suct lift)
17.	20 (2 stage)	54"	84500	960	360	-1 (suct lift)
20.	20 2(stage)	54"	88300	1020	360	-½ (suct lift)

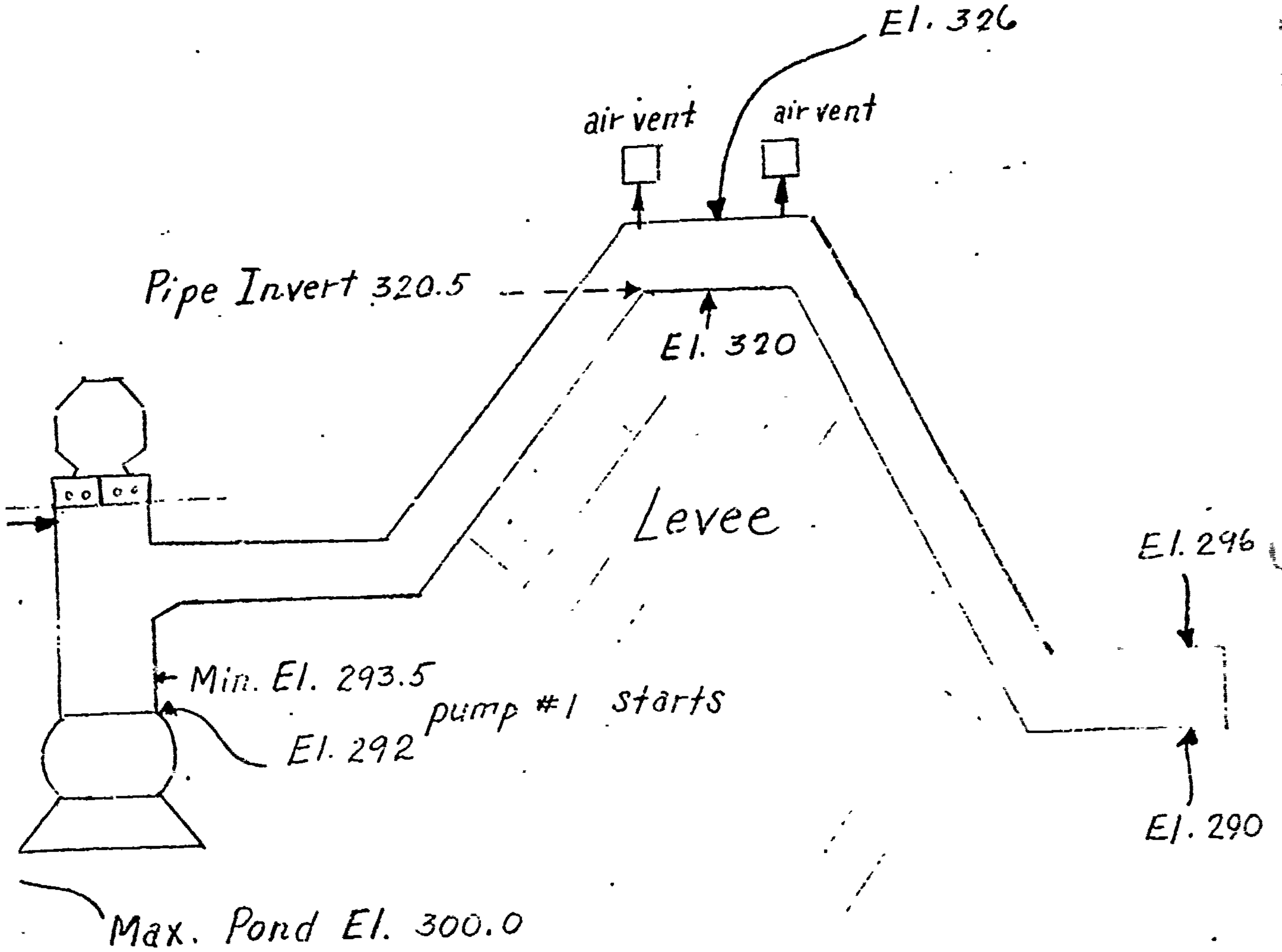
BY ____ DATE ____ SUBJECT Bernville Local Protection Pump Station SHEET NO. ____ OF ____
CHKD. BY ____ DATE ____ JOB NO. ____
P.102

Comparison at 90 000 gpm flow:

Calc No.	BHP	Available Head
1.	1240	44.5
2.	1162	40.5
3.	1220	47.5
4.	1345	49.0
5.	1006	36.8
6.	1120	39.5
7.	1003	39.2
8.	1155	43.5
9.	1150	44.0
10.	976	37.5
11.	1300	45.0
12.	1175	41.0
13.	1460	52.0
14.	1080	38.0
15.	1220	45.5
16.	950	33.0
17.	1010	36.5
18	975	36.0
19	935	33.8
20	1008	36.4

DATE	SUBJECT Bernville Local Protection Pump Station	SHEET NO. 1 OF 8
HKD. BY DATE		JOB NO.
		p.103

Calculation No. 5 based on Curve Plate 21A



4 pumps plus sewage and seepage pumps, over levee discharge

Total 360,000 gpm at min. pool elevation 800 cfs

Static head 28.5 ft. to invert of pipe over levee

Discharge line $= \left(\dfrac{4 \times 269.6}{10\pi}\right)^{1/2} = 5.85$ ft. $= 70.3''$

Use 72" dia.

90,000 gpm; 7.09 ft./sec.; .78 ft. Vel. hd.; .277 ft. hd./100 ft.

.78 ft. Vel. head
.559 ft. frict. head

4 elbows (45°) @ K = .45

$h = [.0155\,(7.09)^2\,(.45)] \times 4$ elbows $= 1.4$ ft.

1.4 ft. elbow frict. head
6.0 ft. for head of pipe over levee above invert
28.5 ft. static head

37.23 ft. TDH

Use TDH of 37.23 ft.

Plate 21 A (72,000 gpm Prototype Req'd Capacity)

1. TDH = 37.23 ft.

2. Pump Capacity for Plate 21A

$$Q_m = 7400$$

3. Pump Diameter

$$D_p = D_m\left(\frac{Q_p}{Q_m}\right)^{1/2} = 16\left(\frac{72000}{7400}\right)^{1/2} = 49.2''$$

Use 60" Diameter Pump

4. Redetermine Flow Capacity

$$Q_m = Q_p\left(\frac{D_m}{D_p}\right)^2 = 72000\left(\frac{16}{60}\right)^2 = 5120.0$$

5. Plot Line of Constant Specific Speed

$$Q_x = Q_c\left(\frac{H_x}{H_c}\right)^{1/2} = 5120.0\left(\frac{H_x}{37.23}\right)^{1/2}$$

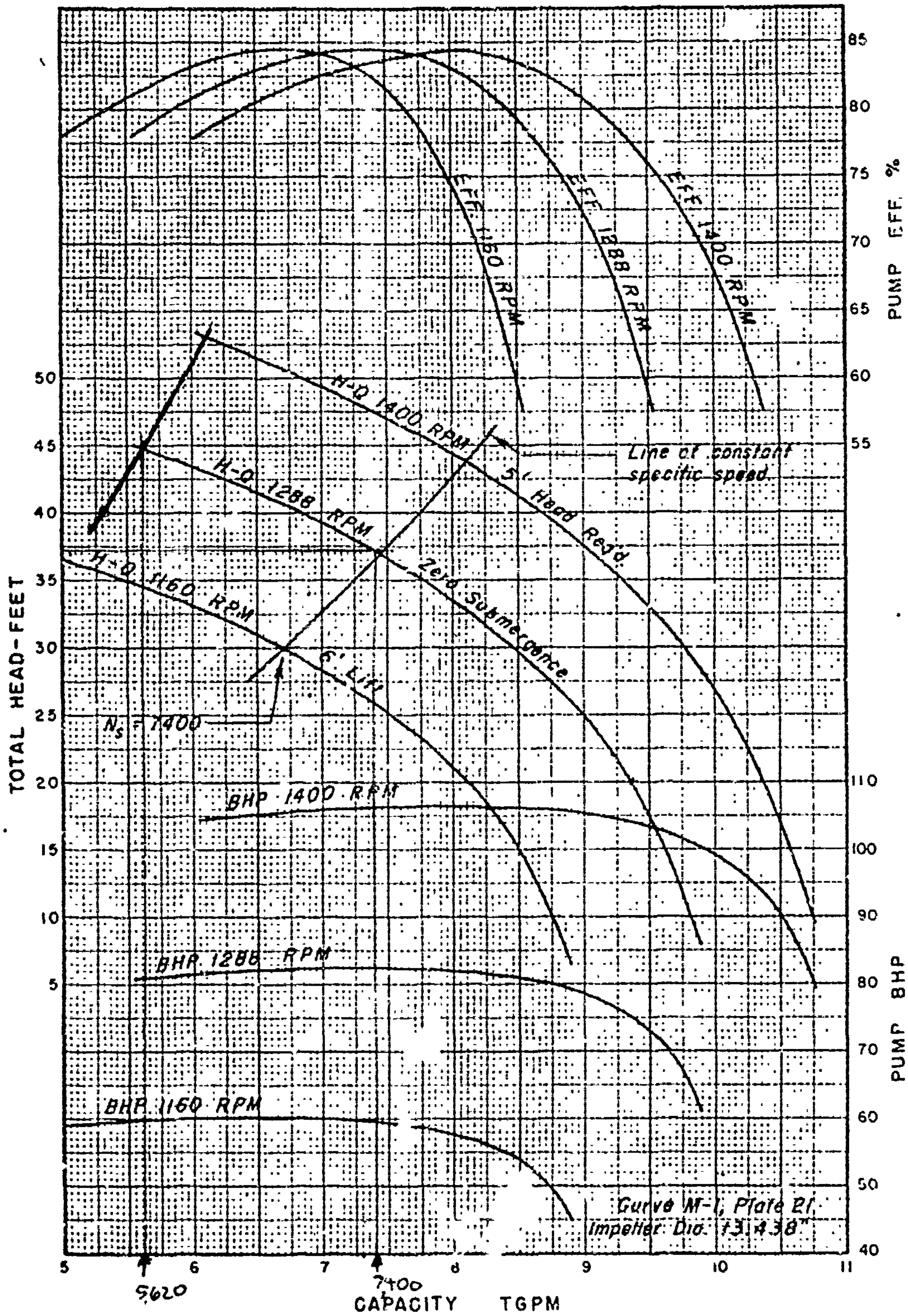
H_x	Q_x
40	5307
45	5629
50	5933

6. Model Flow Capacity

$$Q_x = 5620 \text{ gpm}$$

7. Model Speed

$$N_c = N_x\left(\frac{Q_c}{Q_x}\right) = 1288\left(\frac{5120}{5620}\right) = 1173.4 \text{ rpm}$$



16" MIXED-FLOW MODEL PUMP PERFORMANCE CURVES

PLATE NO. 21A

8. Model Pump Curve

$$Q_c = Q_x\left(\frac{N_c}{N_x}\right) = \left(\frac{1173.4}{1288}\right)Q_x$$

See Calculations

$$H_c = H_x\left(\frac{N_c}{N_x}\right)^2 = \left(\frac{1173.4}{1288}\right)^2 H_x$$

$$P_c = P_x\left(\frac{N_c}{N_x}\right)^3 = \left(\frac{1173.4}{1288}\right)^3 P_x$$

9. Prototype Pump Curve

$$H_p = H_m$$

$$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = \left(\frac{60}{16}\right)^2 Q_m$$

$$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = \left(\frac{60}{16}\right)^2 P_m$$

10. Prototype Pump Speed

$$N_p = \left(\frac{D_m}{D_p}\right) N_m = \left(\frac{16}{60}\right)1288 = 343.5 \text{ rpm}$$

11. Synchronous Prototype (360 rpm)

$$Q_x = Q_c\left(\frac{N_x}{N_c}\right) = Q_c\left(\frac{360}{343.5}\right)$$

$$H_x = H_c\left(\frac{N_x}{N_c}\right)^2 = H_c\left(\frac{360}{343.5}\right)^2$$

$$P_x = P_c\left(\frac{N_x}{N_c}\right)^3 = P_c\left(\frac{360}{343.5}\right)^3$$

12. Working Calculations For Synchronous Prototype Pump Curve

$$Q_{xf} = \left(\frac{360}{343.5}\right)\left(\frac{60}{16}\right)^2\left(\frac{1173.4}{1288}\right)Q_{xi} = 13.42\, Q_{xi}$$

$$H_{xf} = \left(\frac{360}{343.5}\right)^2\left(\frac{1173.4}{1288}\right)^2 H_{xi} = .91\, H_{xi}$$

$$P_{xf} = \left(\frac{360}{343.5}\right)^3\left(\frac{60}{16}\right)^2\left(\frac{1173.4}{1288}\right)^3 P_{xi} = 12.23\, P_{xi}$$

BY ______ DATE ______ SUBJECT Bernville Local Protection Pump Station SHEET NO. 6 OF 8
CHKD. BY ______ DATE ______ JOB NO. ______

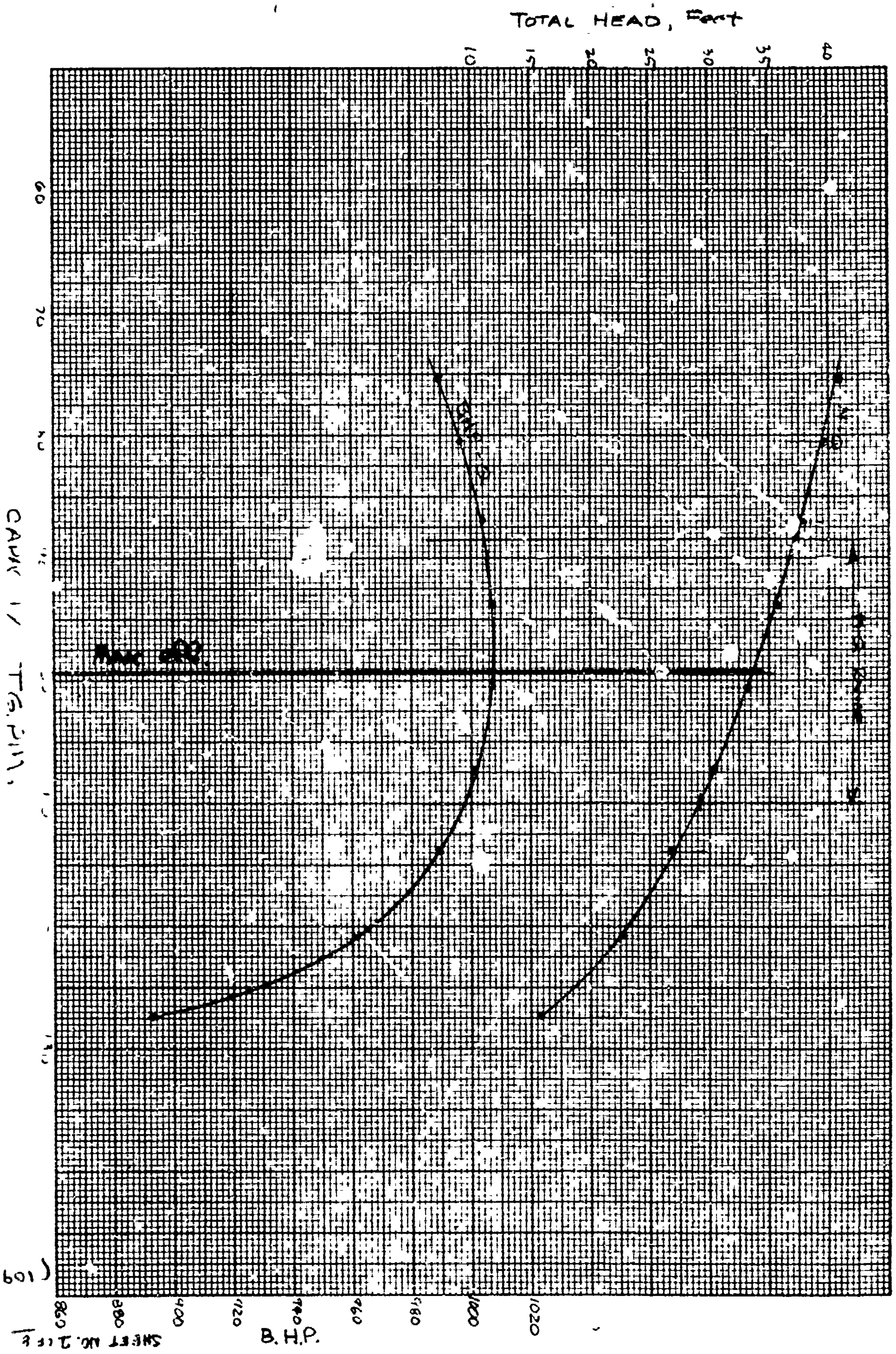
P 108

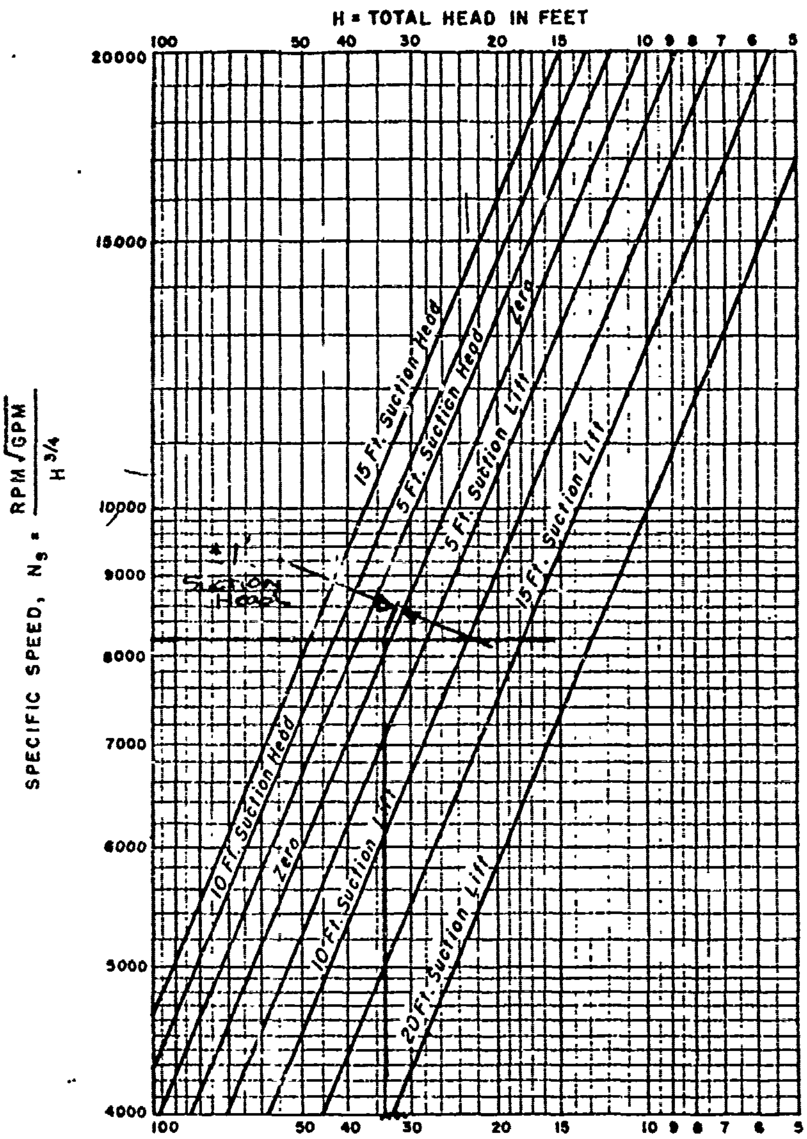
Value From Plate 21 A at Zero Submergence			Prototype Value at 360 rpm Sync.		
Q	H	P	Q	H	P
5620	44.8	80.9	75420	40.8	989.4
6000	43.5	81.5	80520	39.6	996.7
6500	41.6	82.1	87230	37.8	1004.1
7000	39.2	82.4	93940	35.7	1007.8
7500	36.6	82.4	100650	33.3	1007.8
8000	33.4	81.9	107360	30.4	1001.6
8500	29.6	80.9	114070	26.9	989.4
9000	25.0	78.6	120780	22.8	961.3
9500	17.4	73.0	127490	15.8	892.8
Max. Eff. 7400			Max. Eff. 99302		

13. Specific Speed

$$N_S = \frac{rpm\sqrt{gpm}}{H^{.75}} = \frac{360\sqrt{100,000}}{(33.4)^{.75}} = 8193.9$$

About 1' of Suction Head


TOTAL HEAD, Feet
10
15
20
25
30
35
40
B.H.P.

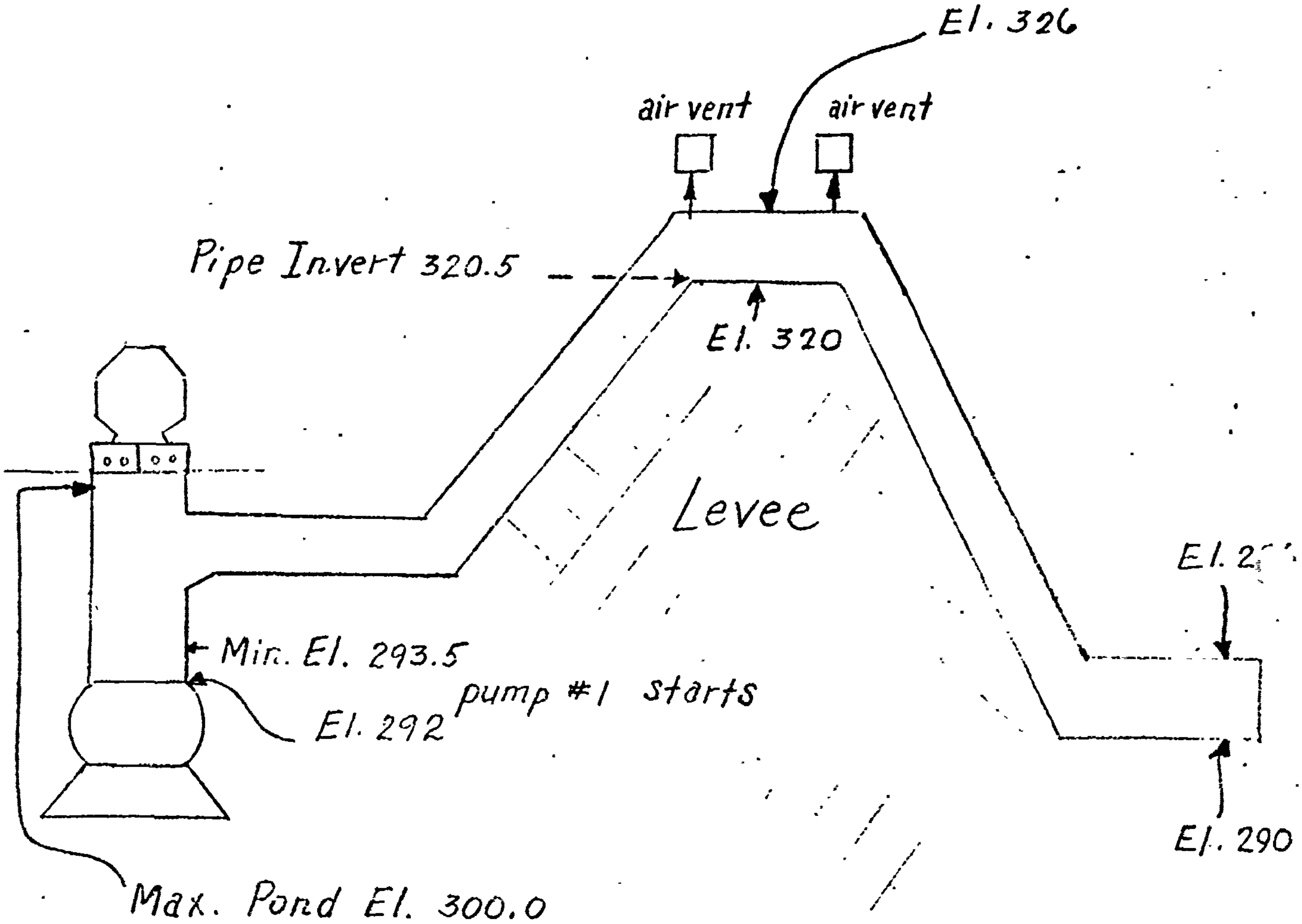


HYDRAULIC INSTITUTE UPPER LIMITS OF SPECIFIC SPEEDS FOR SINGLE-SUCTION PROPELLER AND MIXED-FLOW PUMPS

PLATE NO. 16

BY ______ DATE ______	SUBJECT Bernville Local Protection Pump Station	SHEET NO. 1 OF 10
CHKD. BY ______ DATE ______		JOB NO. ______
		P 111

Calculation No. 10 based on Curve Plate 21 C



4 pumps plus sewage and seepage pumps, over levee discharge

Total 360,000 gpm at min. pool elevation 800 cf

BY	DATE	SUBJECT Bernville Local Protection Pump Station	SHEET NO. 2 OF 10
CHKD. BY	DATE		JOB NO.

p.112

Static head 28.5 ft. to invert of pipe over levee

Discharge line $= \left(\frac{4 \times 269.6}{10\pi}\right)^{1/2} = 5.85$ ft. $= 70.3''$

Use 72" dia.

90,000 gpm; 7.09 ft./sec.; .78 ft. Vel. hd.; .277 ft. hd./100 ft.

.78 ft. Vel. head
.559 ft. frict. head

4 elbows (45°) @ K = .45

$h = [.0155 (7.09)^2 (.45)] \times 4$ elbows $= 1.4$ ft.

1.4 ft. elbow frict. head
6.0 ft. for head of pipe over levee above invert
28.5 ft. static head

37.23 ft. TDH

Use TDH of 37.23 ft.

BY ____ DATE ____ SUBJECT Barnville Local Protection Pump Station SHEET NO. 3 OF 10
CHKD. BY ____ DATE ____ JOB NO. ____
C113

Plate No. 21 C

1. T D H = 37.23 ft. 63,000 gpm (starting pump stage)

2. Pump Capacity per Plate 21 C

Q_m = 6400 gpm

3. Pump Diameter per Model Law

$$D_p = D_m \left(\frac{Q_p}{Q_m}\right)^{1/2} = 16\left(\frac{63,000}{6400}\right)^{1/2} = 50.??$$

Use 60" Diameter Pump

4. New Model Capacity per Model Law

$$Q_m = Q_p \left(\frac{D_m}{D_p}\right)^2 = 63,000\left(\frac{16}{60}\right)^2 = 4480.0 \text{ gpm}$$

5. Plot Line of Constant Specific Speed

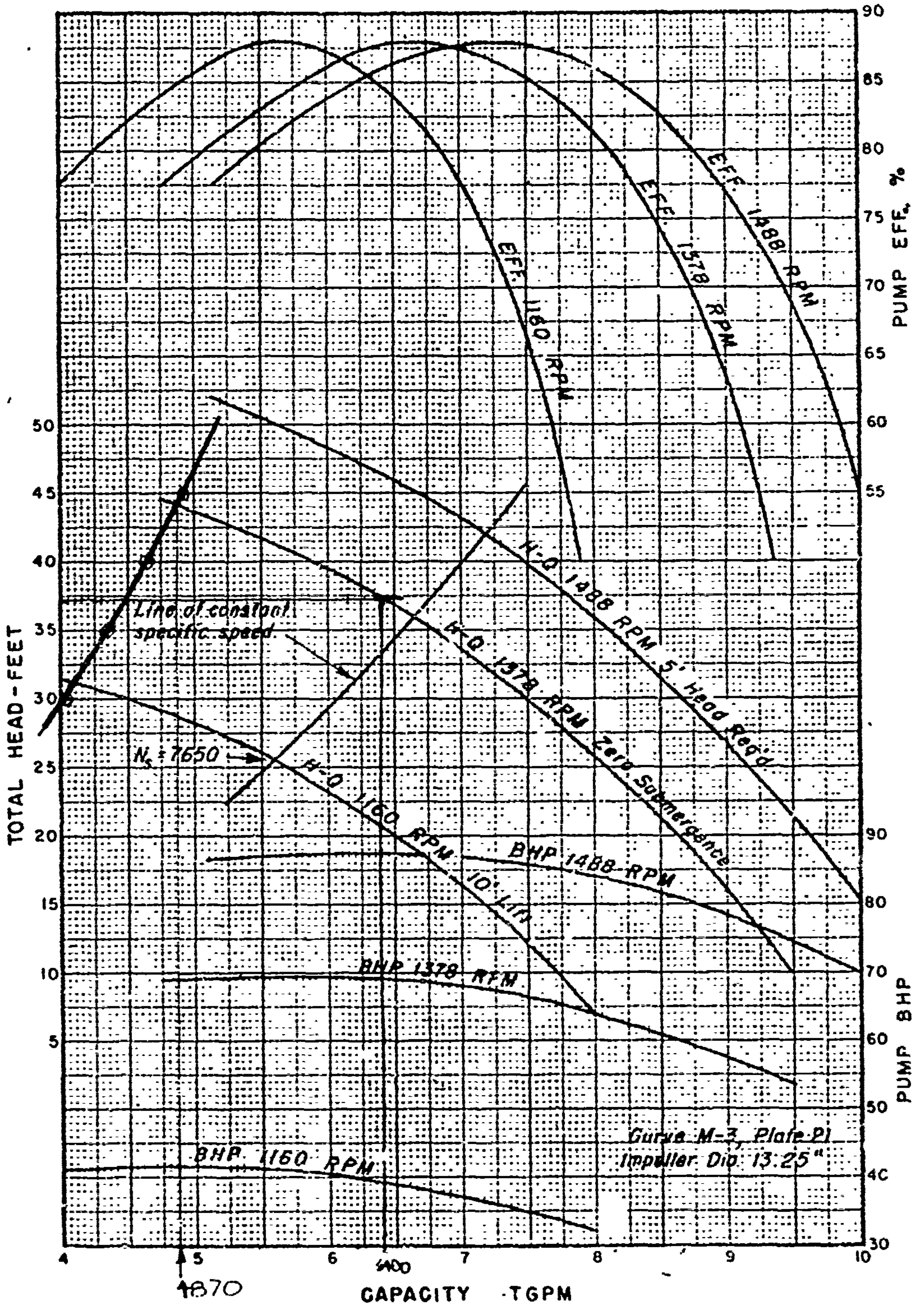
$$Q_x = Q_c \left(\frac{H_x}{H_c}\right)^{1/2} = 4480\left(\frac{H_x}{37.23}\right)^{1/2}$$

H_x	Q_x
20	3283.6
30	4021.5
35	4343.8
40	4643.7
45	4925.4

6. Rpm at Zero Submergence = 1378

7. Capacity per Plate 21 c

Q_x = 4870



16" MIXED-FLOW MODEL PUMP PERFORMANCE CURVES

PLATE NO. 21C

8. Model Speed

$$N_c = N_x\left(\frac{Q_c}{Q_x}\right) = 1378\left(\frac{4480}{4870}\right) = 1267.6 \text{ rpm}$$

9. Model Curve Plot

$$Q_c = Q_x\left(\frac{N_c}{N_x}\right) = Q_x\left(\frac{1267.6}{1378}\right)$$

$$H_c = H_x\left(\frac{N_c}{N_x}\right)^2 = H_x\left(\frac{1267.6}{1378}\right)^2$$

$$P_c = P_x\left(\frac{N_c}{N_x}\right)^3 = P_x\left(\frac{1267.6}{1378}\right)^3$$

See computations for work

10. Prototype Speed

$$N_p = \left(\frac{D_m}{D_p}\right)N_m = \frac{16}{60}(1378) = 367.47 \text{ rpm}$$

11. Prototype Curve Plot

$$H_p = H_m$$

$$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = \left(\frac{60}{16}\right)^2 Q_m$$

$$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = \left(\frac{60}{16}\right)^2 P_m$$

See computations for work

12. Synchronous Prototype Curve

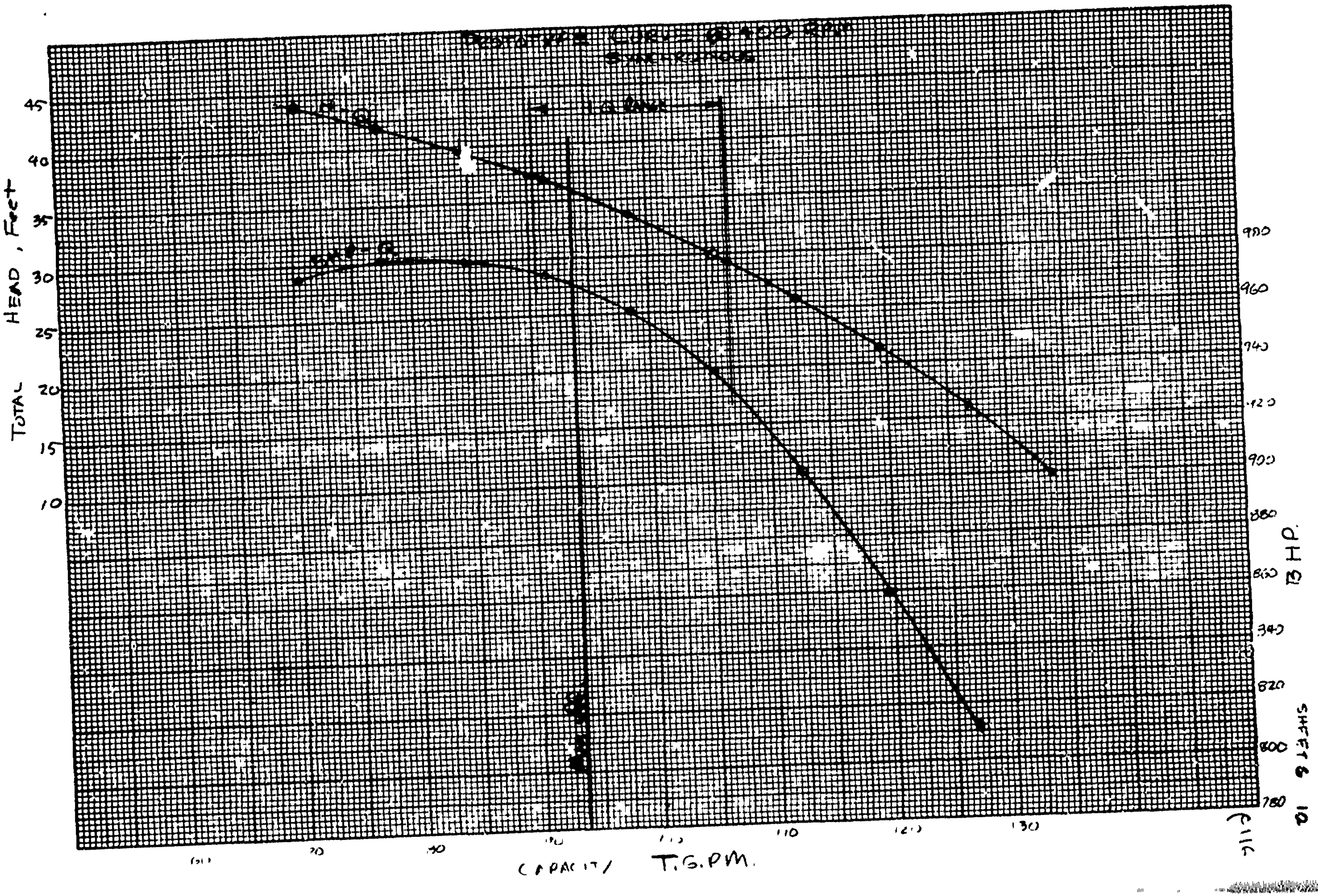
$$H_x = H_c\left(\frac{N_x}{N_c}\right)^2 = H_c\left(\frac{400}{367.47}\right)^2$$

$$Q_x = Q_c\left(\frac{N_x}{N_c}\right) = Q_c\left(\frac{400}{367.47}\right)$$

$$P_x = P_c\left(\frac{N_x}{N_c}\right)^3 = P_c\left(\frac{400}{367.47}\right)^3$$

See computations for work

K+E 10 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO



13. Computations for Final Prototype Graph

$$Q_{xf} = \left(\frac{400}{367.47}\right)\left(\frac{60}{16}\right)^2\left(\frac{1267.6}{1378}\right) Q_{xi} = 14.08\, Q_{xi}$$

$$H_{xf} = \left(\frac{400}{367.47}\right)^2\left(\frac{1267.6}{1378}\right)^2 H_{xi} = 1.003\, H_{xi}$$

$$P_{xf} = \left(\frac{400}{367.47}\right)^3\left(\frac{60}{16}\right)^2\left(\frac{1267.6}{1378}\right)^3 P_{xi} = 14.12\, P_{xi}$$

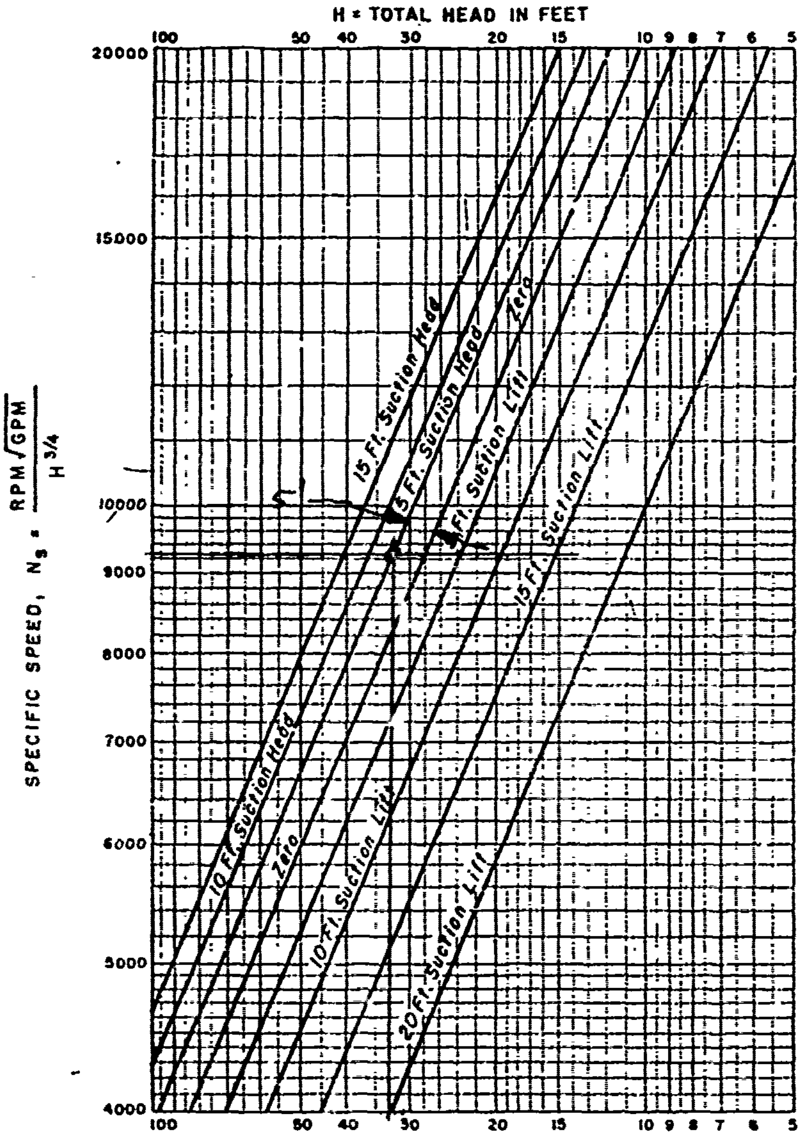
Values from Plate 21 C Zero Submergence Curve: Q	H	P	Final Prototype Values at 400 rpm Sync. Q	H	P
5000	43.7	69.1	70400	43.8	975.7
5500	41.7	69.5	77440	41.8	981.3
6000	39.5	69.4	84480	39.6	979.9
6500	36.8	69.0	91520	36.9	974.3
7000	33.6	68.0	98560	33.7	960.2
7500	29.9	66.5	105,600	30.0	939.0
8000	25.8	63.9	112,640	25.9	902.3
8500	21.3	60.9	119,680	21.4	859.9
9000	16.0	57.5	126,720	16.0	811.9
9500	9.9	53.5	133,760	9.9	755.4

Max. Eff. 6650   Max Eff. 93632

14. Specific Speed

$$N_s = \frac{\text{rpm}\sqrt{\text{gpm}}}{H^{.75}} = \frac{400\sqrt{100{,}000}}{(32.8)^{.75}} = 9228.98$$

[About 5' Suction Head]



HYDRAULIC INSTITUTE UPPER LIMITS OF SPECIFIC SPEEDS FOR SINGLE-SUCTION PROPELLER AND MIXED-FLOW PUMPS

CALCULATIONS OF FLOW, HORSEPOWER & SPECIFIC SPEEDS FOR LOW HEADS

1. CALCULATIONS

$$Q_{xf} = 14.08\, Q_{xi}$$

$$H_{xf} = 1.003\, H_{xi}$$

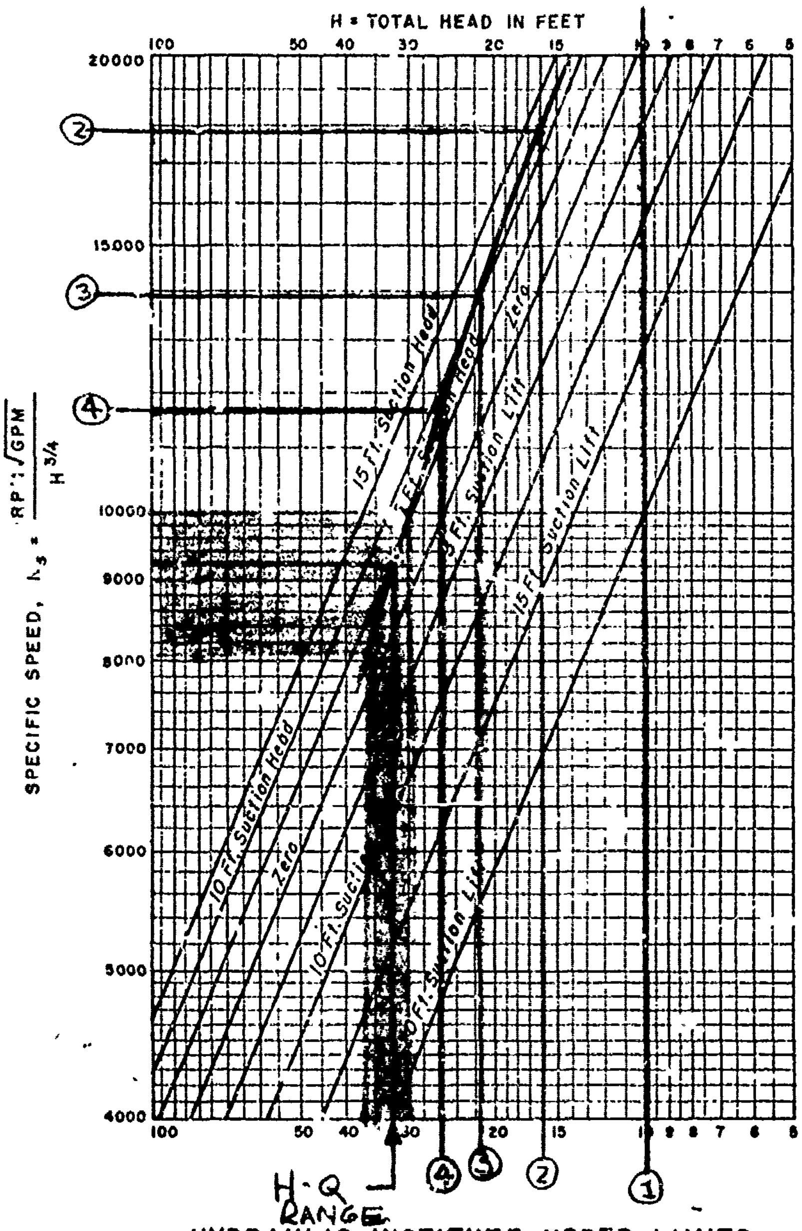
$$P_{xf} = 14.12\, P_{xi}$$

VALUES FROM PLATE 21C ZERO SUBMERGENCE CURVE			FINAL PROTOTYPE VALUES @ 400 RPM SYNCH.		
Q	H	P	Q	H	P
9500	9.9	53.5	133,760	9.9	755.4
9000	16.0	57.5	126,720	16.0	811.9
8500	21.3	60.9	119,680	21.4	859.9
8000	25.8	63.9	112,640	25.9	902.3

2 SPECIFIC SPEED

$$N_s = \frac{RPM\sqrt{G.PM}}{H^{.75}} = \frac{400\sqrt{G.P.M}}{H^{.75}}$$

POINT No	CAPACITY (gpm)	HEAD (ft)	N_s	REMARKS
1	133,760	9.9	26,211.0	OUT OF RANGE
2	126,720	16.0	17,798.9	±12' SUCTION HEAD
3	119,680	21.4	13,907.9	±10' SUCTION HEAD
4	112,640	25.9	11,693.1	±8' SUCTION HEAD



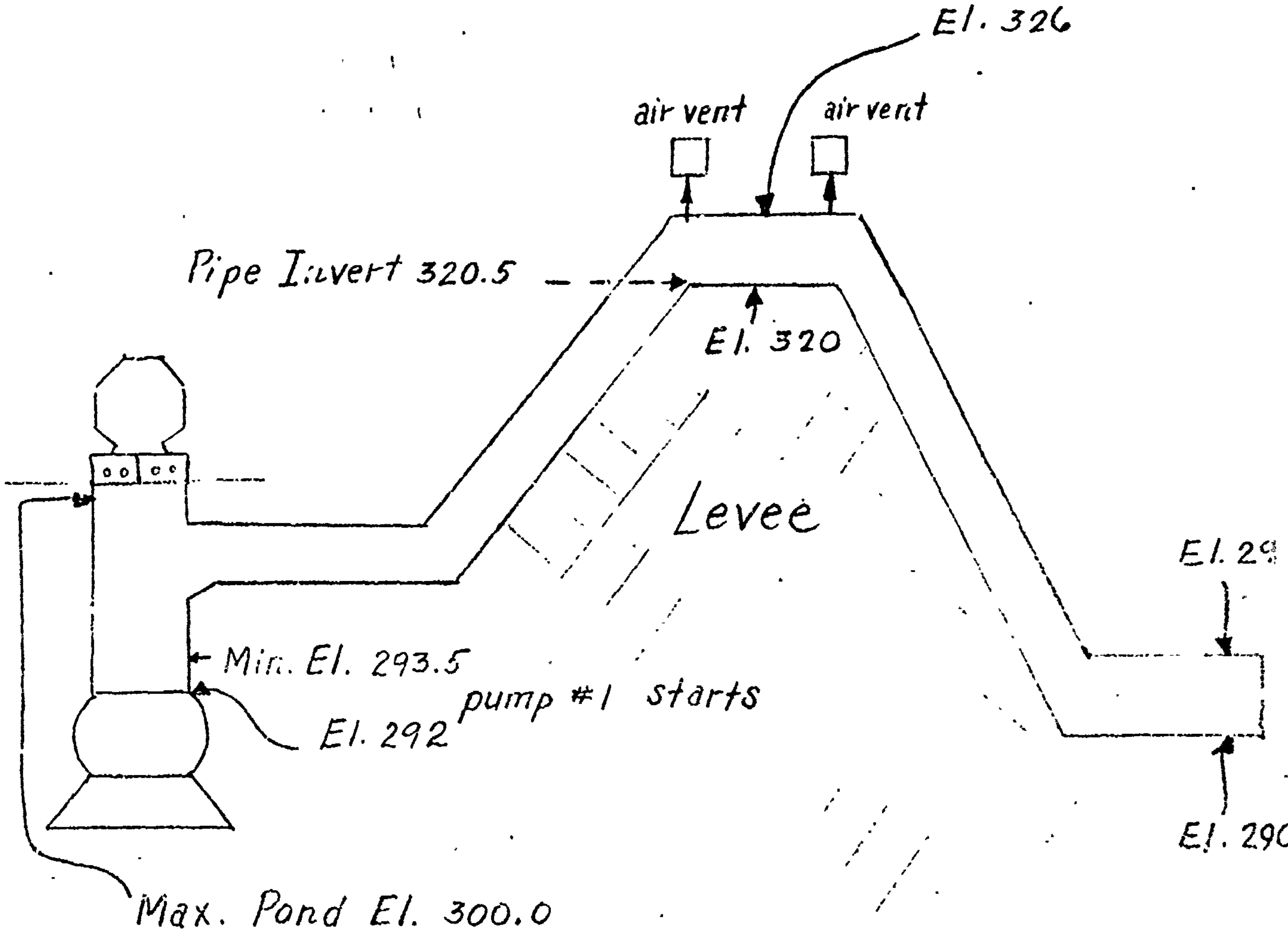
HYDRAULIC INSTITUTE UPPER LIMITS OF SPECIFIC SPEEDS FOR SINGLE-SUCTION PROPELLER AND MIXED-FLOW PUMPS

PLATE NO. 16

BY ________ DATE ________ SUBJECT Bernville Local Protection Pump Station SHEET NO. 1 OF 10

CHKD. BY ________ DATE ________ JOB NO. ________

Calculation No. 18 based on Curve Plate 18



4 pumps plus sewage and seepage pumps, over levee discharge

Total 360,000 gpm at min. pool elevation 800 cfs.

BY ______ DATE ______	SUBJECT Bernville Local	SHEET NO. 2 OF 10
CHKD. BY ______ DATE ______	Protection Pump Station	JOB NO. ______
		f.122

Static head 28.5 ft. to invert of pipe over levee

$$\text{Discharge line} = \left(\frac{4 \times 269.6}{10\pi}\right)^{1/2} = 5.85 \text{ ft.} = 70.3''$$

Use 72" dia.

90,000 gpm; 7.09 ft./sec.; .78 ft. Vel. hd.; .277 ft. hd./100 ft.

.78 ft. Vel. head
.559 ft. frict. head

4 elbows (45°) @ K = .45

$$h = [.0155\,(7.09)^2\,(.45)] \times 4 \text{ elbows} = 1.4 \text{ ft.}$$

1.4 ft. elbow frict. head
6.0 ft. for head of pipe over levee above invert
28.5 ft. static head

37.23 ft. TDH

Use Plate No. 18, 20" model w/ TDH of 37.23 ft.

PLATE 18 20" AXIAL FLOW

1. T.D.H FOR TWO STAGE PUMP = 37.23 ft.

   HEAD PER STAGE = 18.61 ft

2. CAPACITY PER PLATE 18

   $Q_m = 14,600$ gpm

3. DETERMINE PUMP DIAMETER

   $D_P = D_m\left(\frac{Q_P}{Q_m}\right)^{1/2} = 20\left(\frac{90,000}{14,600}\right)^{1/2} = 49.6''$

   USE 54" DIA. PUMP

4. DETERMINE NEW MODEL FLOW

   $Q_m = Q_P\left(\frac{D_P}{D_m}\right)^2 = 90,000\left(\frac{20}{54}\right)^2 = 12,345.7$

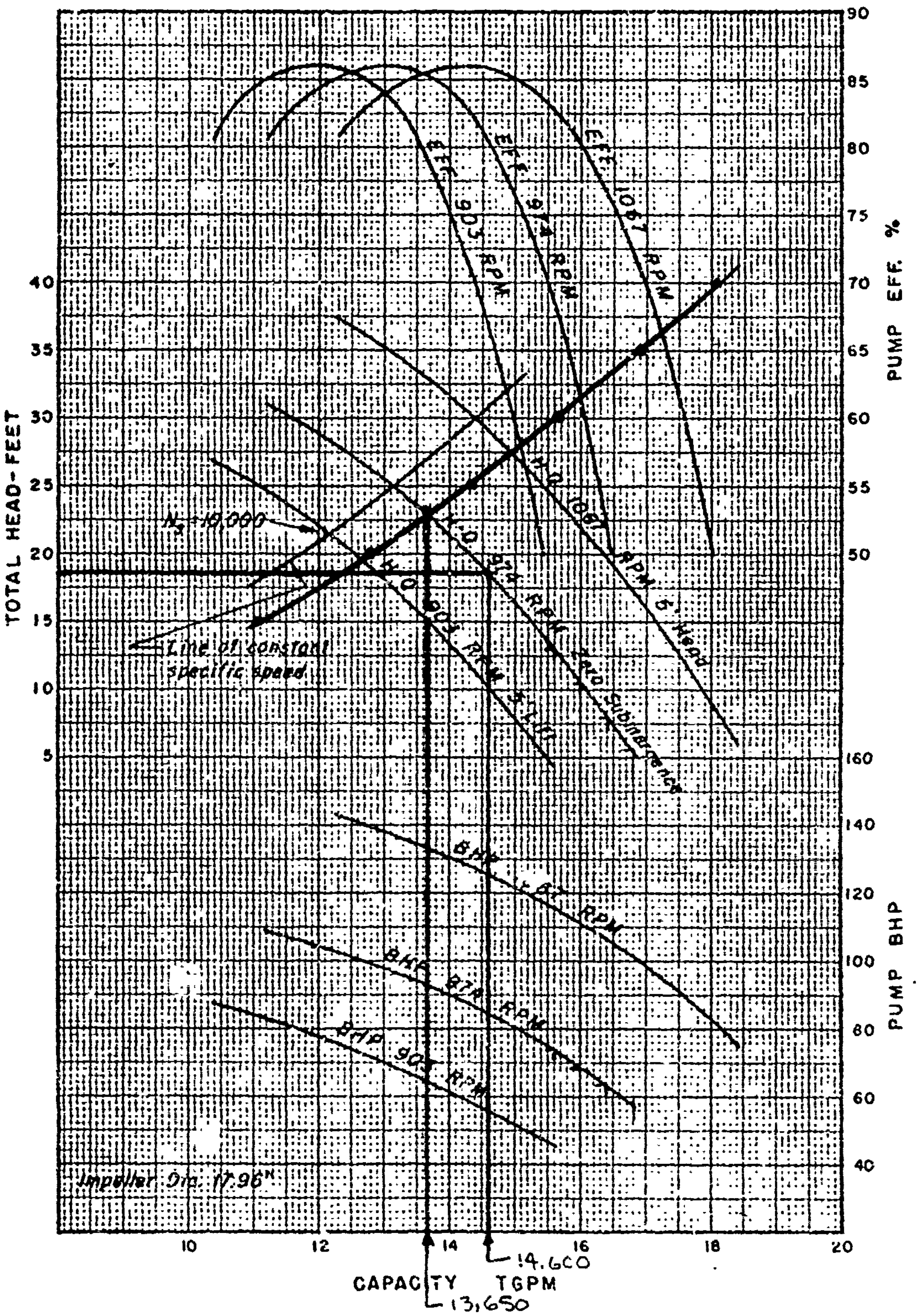
5. PLOT LINE OF CONSTANT SPECIFIC SPEED

   $Q_x = Q_c\left(\frac{H_x}{H_c}\right)^{1/2} = 12,345.7\left(\frac{H_x}{18.61}\right)^{1/2}$

H_x	Q_x
15	11,083.8
20	12,798.4
25	14,309.1
30	15,674.8
35	16,930.8

6. MODEL CURVE SPEED

   $N_c = N_x\left(\frac{Q_c}{Q_x}\right) = 974\left(\frac{12,345.7}{13,650}\right) = 880.9$



AXIAL-FLOW MODEL PUMP PEFORMANCE CURVES

PLATE NO 18

7. MODEL CURVE PLOT

$Q_c = Q_x\left(\frac{N_c}{N_x}\right) = \left(\frac{880.9}{974}\right) Q_x = .90\ Q_x$ SEE FINAL CALCULATIONS

$H_c = H_x\left(\frac{N_c}{N_x}\right)^2 = (.90)^2 H_x = .81 H_x$

$P_c = P_x\left(\frac{N_c}{N_x}\right)^3 = (.90)^3 P_x = .73 P_x$

8. PROTOTYPE CURVE PLOT

$H_P = H_m$

$Q_P = Q_m\left(\frac{D_P}{D_m}\right)^2 = \left(\frac{54}{20}\right)^2 Q_m = 7.29\ Q_m$ " "

$P_P = P_m\left(\frac{D_P}{D_m}\right)^2 = \left(\frac{54}{20}\right)^2 P_m = 7.29\ P_m$

9. PROTOTYPE PUMP SPEED

$N_P = N_m\left(\frac{D_m}{D_P}\right) = 974\left(\frac{20}{54}\right) = 360.74$ RPM

USE 360 RPM

10. SYNCHRONOUS SPEED PROTOTYPE CORRECTION

$Q_x = Q_c\left(\frac{N_x}{N_c}\right) = \left(\frac{360}{360.7}\right) Q_c = .998\ Q_c$ " "

$H_x = H_c\left(\frac{N_x}{N_c}\right)^2 = (.998)^2 H_c = .996\ H_c$

$P_x = P_c\left(\frac{N_x}{N_c}\right)^3 = (.998)^3 P_c = .994\ P_c$

11. CALCULATIONS

$Q_{xc} = Q_{xi}(.998)(7.29)(.90) = 6.55\ Q_{xi}$

$H_{xc} = H_{xi}(.996)(.81)(2) = 1.61\ H_{xi}$

$P_{xc} = P_{xi}(.994)(7.29)(.73)(2) = 10.58\ P_{xi}$

BY .... DATE .... SUBJECT Bernville Local Protection Pump Station SHEET NO. 6 OF 10

CHKD. BY .... DATE .... JOB NO. ....

C126

Points from Plate 18 Zero Submergence Curve			Points for Prototype @ 360 RPM Synch.		
Q	H	P	Q	H	P
12000	28.8	104.0	78,600	46.4	1100.3
13000	25.6	98.0	85,150	41.2	1036.8
14000	21.4	90.0	91,700	34.4	952.2
15000	16.5	81.0	98,250	26.6	857.0
16000	10.5	69.0	104,800	16.9	730.0
16800	5.0	58.0	110,040	8.1	613.6

Max. Eff. 13100 gpm

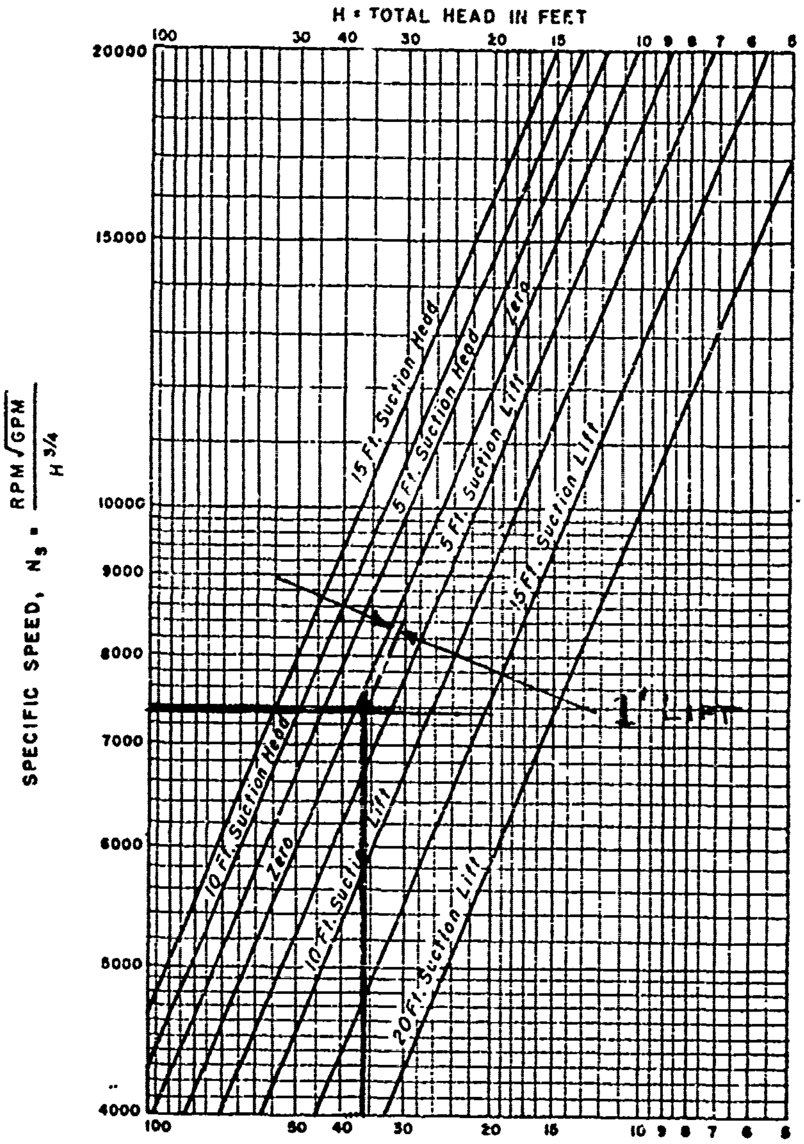
Max. Eff. 85,805

12 Specific Speed

$$N_s = \frac{RPM\sqrt{GPM}}{H^{.75}} = \frac{360\sqrt{90\,000}}{36^{.75}} = 7348.5$$

1' Suction Lift

p 127

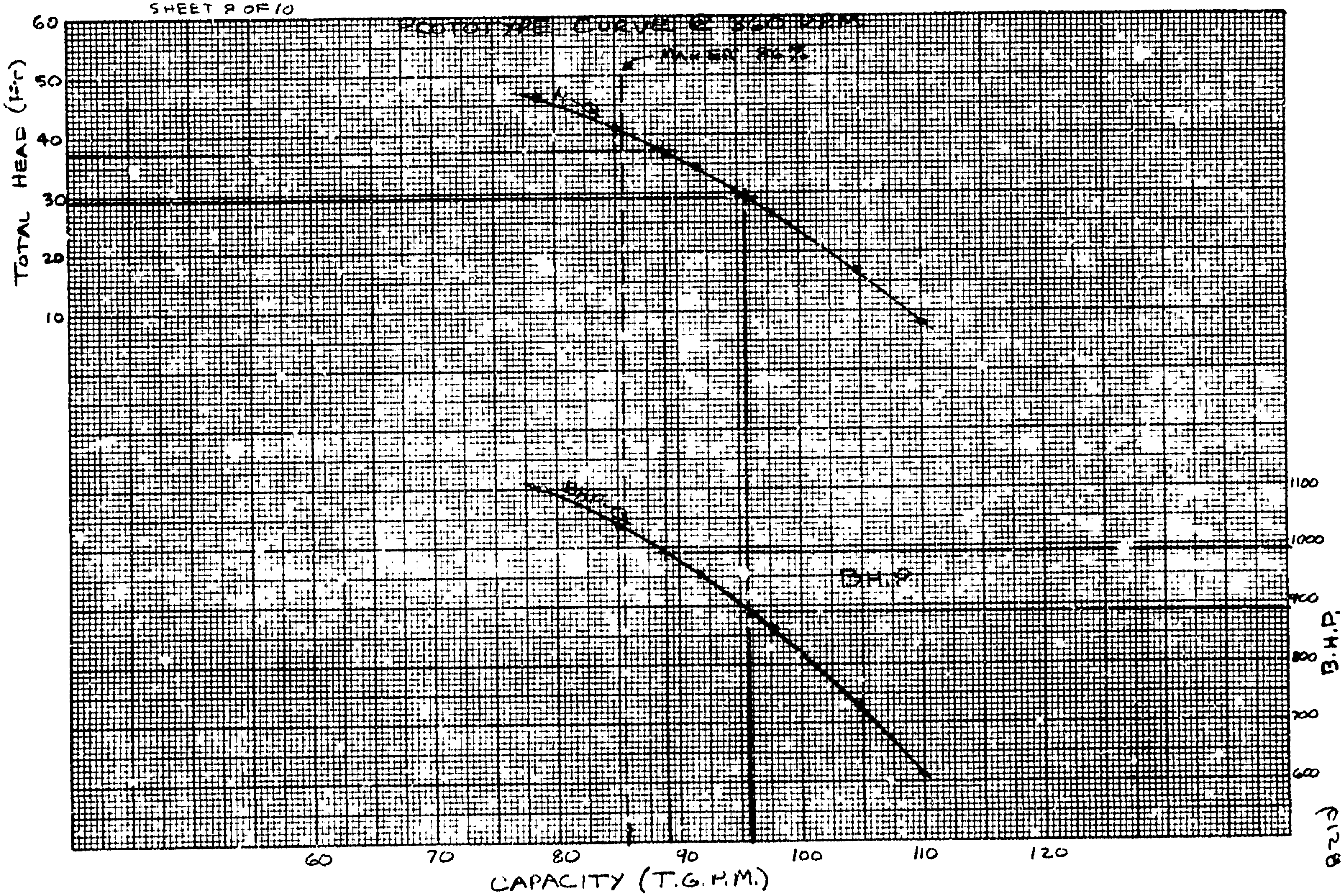


HYDRAULIC INSTITUTE UPPER LIMITS OF SPECIFIC SPEEDS FOR SINGLE-SUCTION PROPELLER AND MIXED-FLOW PUMPS

PLATE NO. 16

K+E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

SHEET 2 OF 10



BY ______ DATE ______	SUBJECT ______	SHEET NO. 9 OF 10
CHKD. BY ______ DATE ______		JOB NO. ______
		P129

PLATE 18 HORSEPOWER, FLOW AND SPECIFIC SPEEDS AT LOW HEAD

1. CALCULATIONS AT LOW HEAD

$Q_{xf} = 6.55\ Q_{xi}$

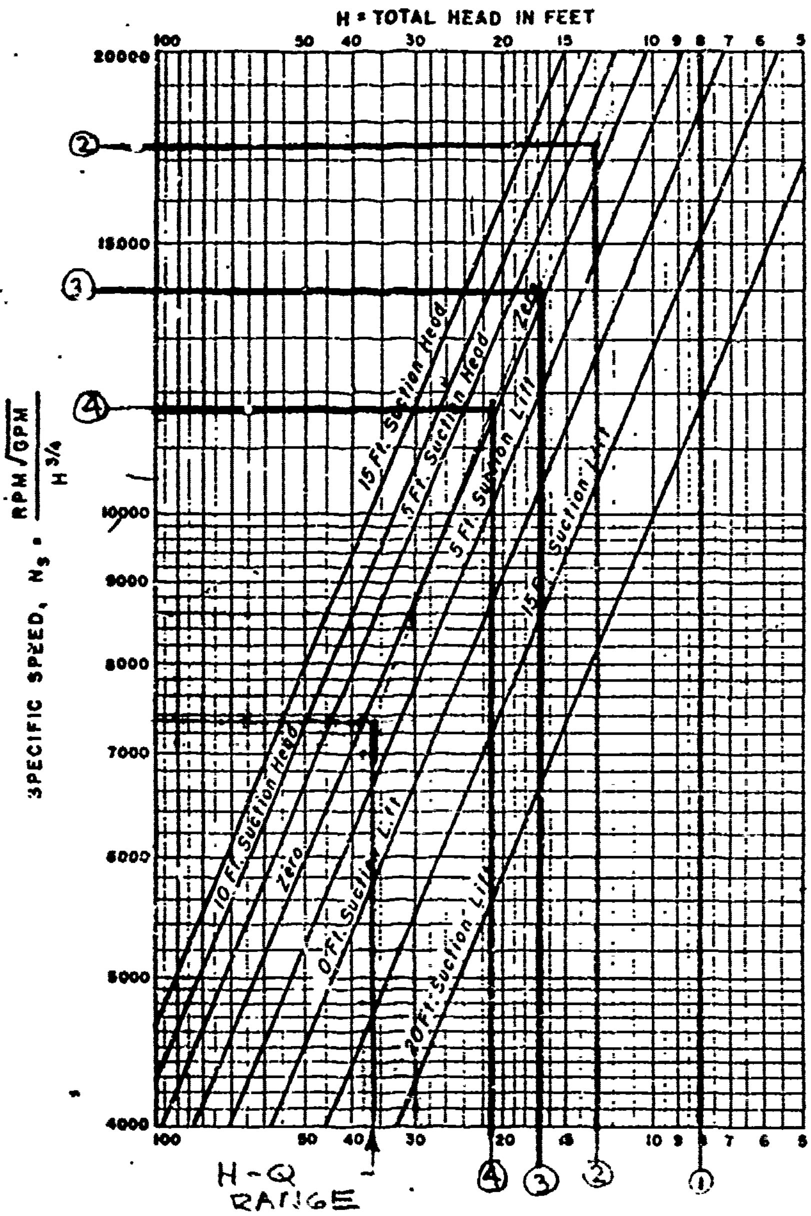
$H_{xf} = 1.61\ H_{xi}$

$P_{xf} = 10.58\ P_{xi}$

Q	H	P	Q	H	P
16,800	5.0	58.0	110,040	8.05	613.6
16400	8.0	64.0	107,420	12.88	677.1
16000	10.5	69.0	104,800	16.90	720.0
15,600	13.0	74.0	102,180	20.93	782.9

2. SPECIFIC SPEEDS $N_s = \frac{RPM \sqrt{GPM}}{H^{.75}}$

POINT No	CAPACITY gpm	HEAD (ft)	N_s	REMARKS
1	110,040	8.0	25,105	OUT OF RANGE
2	107,420	12.9	17,334	± 2' SUCTION HEAD
3	104,300	16.9	13,982	± ½' SUCTION HEAD
4	102,180	20.9	11,773	± 0 SUCTION HEAD



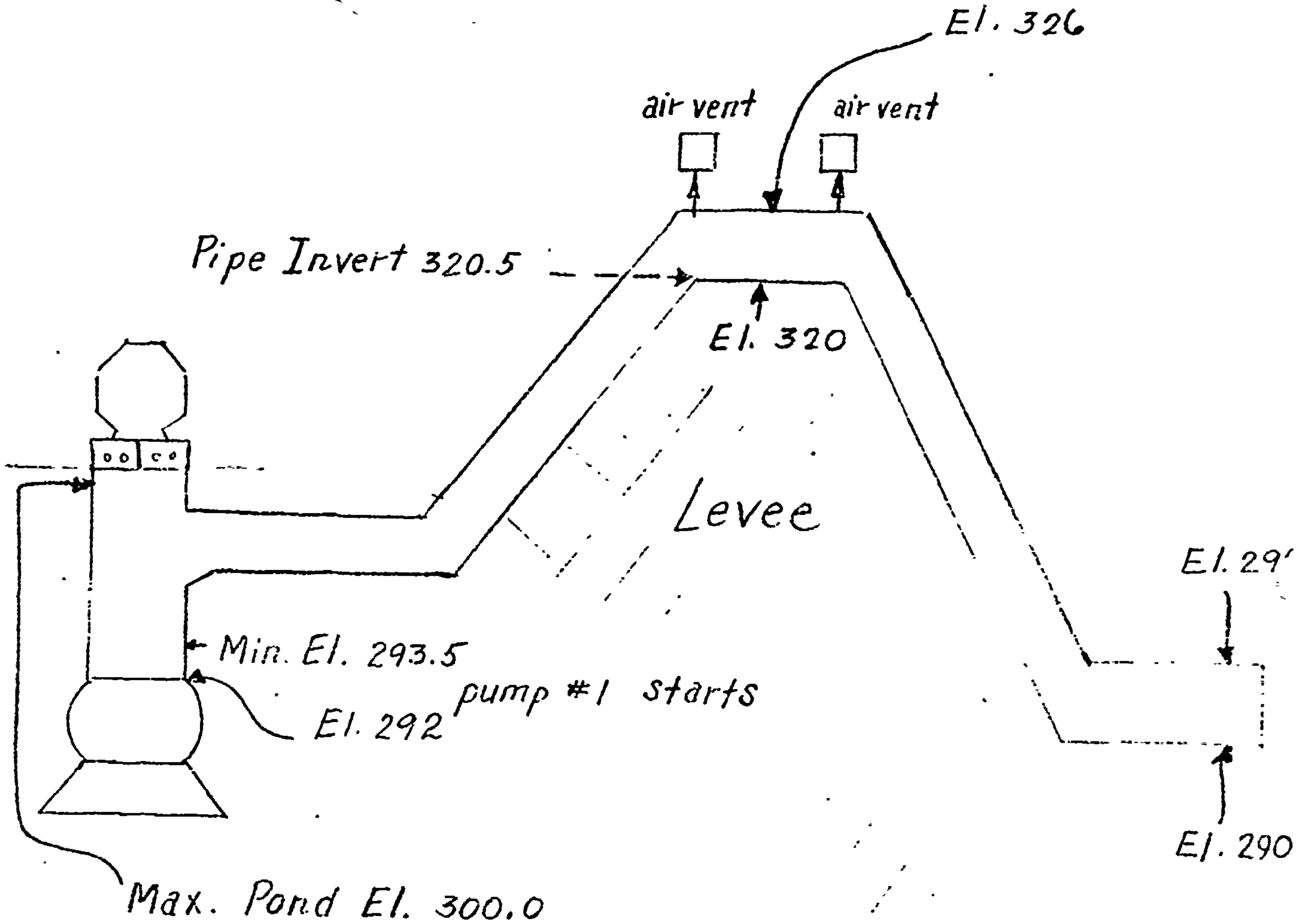
HYDRAULIC INSTITUTE UPPER LIMITS OF SPECIFIC SPEEDS FOR SINGLE-SUCTION PROPELLER AND MIXED-FLOW PUMPS

PLATE NO. 16

BY ____ DATE ____ SUBJECT Bernville Local Protection Pump Station SHEET NO. 1 OF 8
CHKD. BY ____ DATE ____ JOB NO. ____

P131

Calculation No. 19 based on Curve Plate 20



4 pumps plus sewage and seepage pumps, over levee discharge

Total 360,000 gpm at min. pool elevation 800 cfs

BY ________ DATE ________ SUBJECT Bernville Local Protection Pump Station SHEET NO. 2 OF 8

CHKD. BY ________ DATE ________ JOB NO. ________

9132

Static head 28.5 ft. to invert of pipe over levee

$$\text{Discharge line} = \left(\frac{4 \times 269.6}{10\pi}\right)^{1/2} = 5.85 \text{ ft.} = 70.3''$$

Use 72" dia.

90,000 gpm; 7.09 ft./sec.; .78 ft. Vel. hd.; 277 ft. hd./100 ft.

.78 ft. Vel. head
.559 ft. frict. head

4 elbows (45°) @ K = .45

$h = [.0155 (7.09)^2 (.45)] \times 4 \text{ elbows} = 1.4 \text{ ft.}$

1.4 ft. elbow frict. head
6.0 ft. for head of pipe over levee above invert
28.5 ft. static head

37.23 ft. TDH

Use Plate No. 20, 21" model w/ TDH of 37.23 ft.

BY ______ DATE ______ SUBJECT BERNVILLE LOCAL PROTECTION PUMP STATION SHEET NO. 3 OF 8

CHKD. BY ______ DATE ______ JOB NO. ______

f.123

PLATE № 20 , 21" MIXED FLOW

1. T.D.H. = 37.23 ft.

   HEAD PER STAGE = 18.61 ft.

2. DETERMINE FLOW PER PLATE 20

   $Q_m = 16,400\ gpm$

3. DETERMINE PUMP DIAMETER

   $D_P = D_m\left(\frac{Q_P}{Q_m}\right)^{1/2} = 21\left(\frac{90,000}{16,400}\right)^{1/2} = 49.19"$

   USE 54" DIA. PUMP

4. NEW FLOW CAPACITY

   $Q_m = Q_P\left(\frac{D_m}{D_P}\right)^2 = 90,000\left(\frac{[illegible]}{[illegible]}\right)^2 =$ 13,[illegible].1 gpm

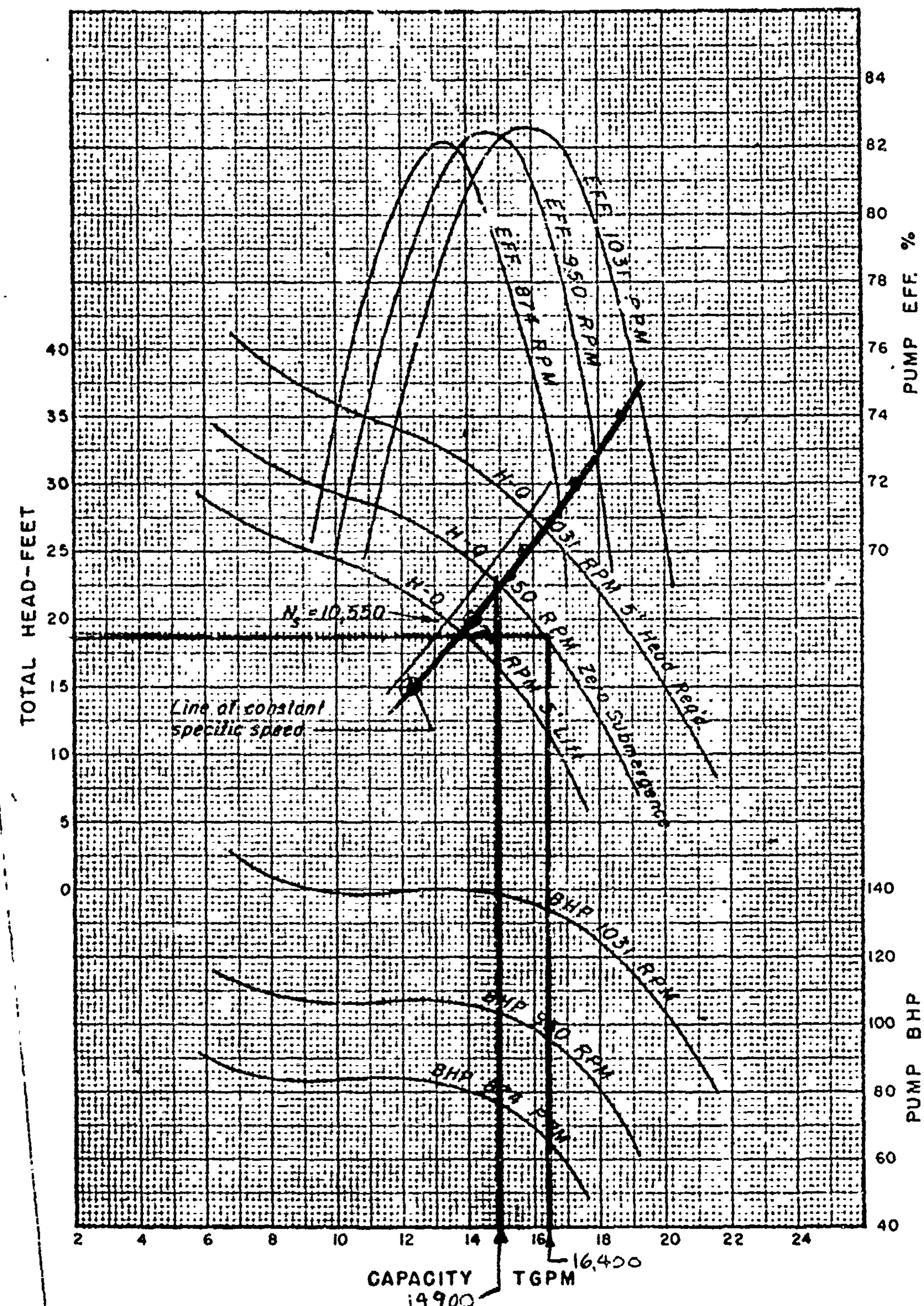
5. LINE OF CONSTANT SPEED

   $Q_x = Q_c\left(\frac{H_x}{H_c}\right)^{1/2} = 13,611.1\left(\frac{H_x}{18.61}\right)^{1/2}$

H_x	Q_x
15	12,219.8
20	14,110.3
25	15,775.[illegible]
30	17,281.5
35	18,6[illegible].1

6 MODEL SPEED

   $N_c = N_x\left(\frac{Q_c}{Q_x}\right) = 950\left(\frac{13,611.1}{[illegible]}\right) =$ [illegible]



21" MIXED-FLOW MODEL PUMP PERFORMANCE CURVES

PLATE NO. 20

7 NEW MODEL PLOT

$Q_c = Q_x\left(\frac{N_c}{N_x}\right) = Q_x\left(\frac{867.8}{950}\right) = .91 Q_x$

$H_c = H_x\left(\frac{N_c}{N_x}\right)^2 = (.91)^2 H_x = .83 H_x$ SEE FINAL

$P_c = P_x\left(\frac{N_c}{N_x}\right)^3 = (.91)^3 P_x = .76 P_x$ CALCULATIONS

8 PLOT PROTOTYPE CURVE

$H_p = H_m$

$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = Q_m\left(\frac{54}{21}\right)^2 = 6.61 Q_m$ " "

$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = P_m\left(\frac{54}{21}\right)^2 = 6.61 Q_m$

9 PROTOTYPE SPEED

$N_p = N_m\left(\frac{D_m}{D_p}\right) = 950\left(\frac{21}{54}\right) = 369.4$ RPM

USE 360 RPM SYNCHRONOUS

10 SYNCHRONOUS PROTOTYPE CURVE

$Q_x = Q_c\left(\frac{N_x}{N_c}\right) = Q_c\left(\frac{360}{369.4}\right) = .97 Q_c$ " "

$H_x = H_c\left(\frac{N_x}{N_c}\right)^2 = H_c(.97)^2 = .95 H_c$

$P_x = P_c\left(\frac{N_x}{N_c}\right)^3 = P_c(.97)^3 = .92 P_c$

11 FINAL CALCULATIONS

$Q_{xf} = Q_{xi}\,(.97)(6.61)(.91) = 5.83\, Q_{xi}$

$H_{xf} = H_{xi}\,(.95)(.83)(2) = 1.58\, H_{xi}$

$P_{xf} = P_{xi}\,(.92)(6.61)(.76)(2) = 9.24\, P_{xi}$

BY ______ DATE ______ SUBJECT BERNVILLE LOCAL PROTECTION PUMP STATION SHEET NO. 6 OF 8

CHKD. BY ______ DATE ______ JOB NO. ______

e136

VALUES FROM PLATE 20 ZERO SUBMERGENCE CURVE			PROTOTYPE VALUES @ 360 RPM. SYNCH.		
Q	H	P	Q	H	P
7000	33.1	112.0	40,810	52.3	1034
8000	31.5	109.0	46,640	49.8	1007
9000	30.3	107.0	52,470	47.9	989
10000	29.4	106.0	58,300	46.4	979
11000	28.6	106.5	64,130	45.2	984
12000	27.6	107.5	69,960	43.6	993
13000	26.3	107.0	75,790	41.5	989
14000	24.[illegible]	106.0	81620	38.9	979
16000	19.8	98.0	93,280	31.3	905
18000	17.5	80.[illegible]	104,940	19.7	739
[illegible]	7.6	65.0	110,[illegible]	12.0	600

MAX EFF. 14,600 MAX. EFF 85,118

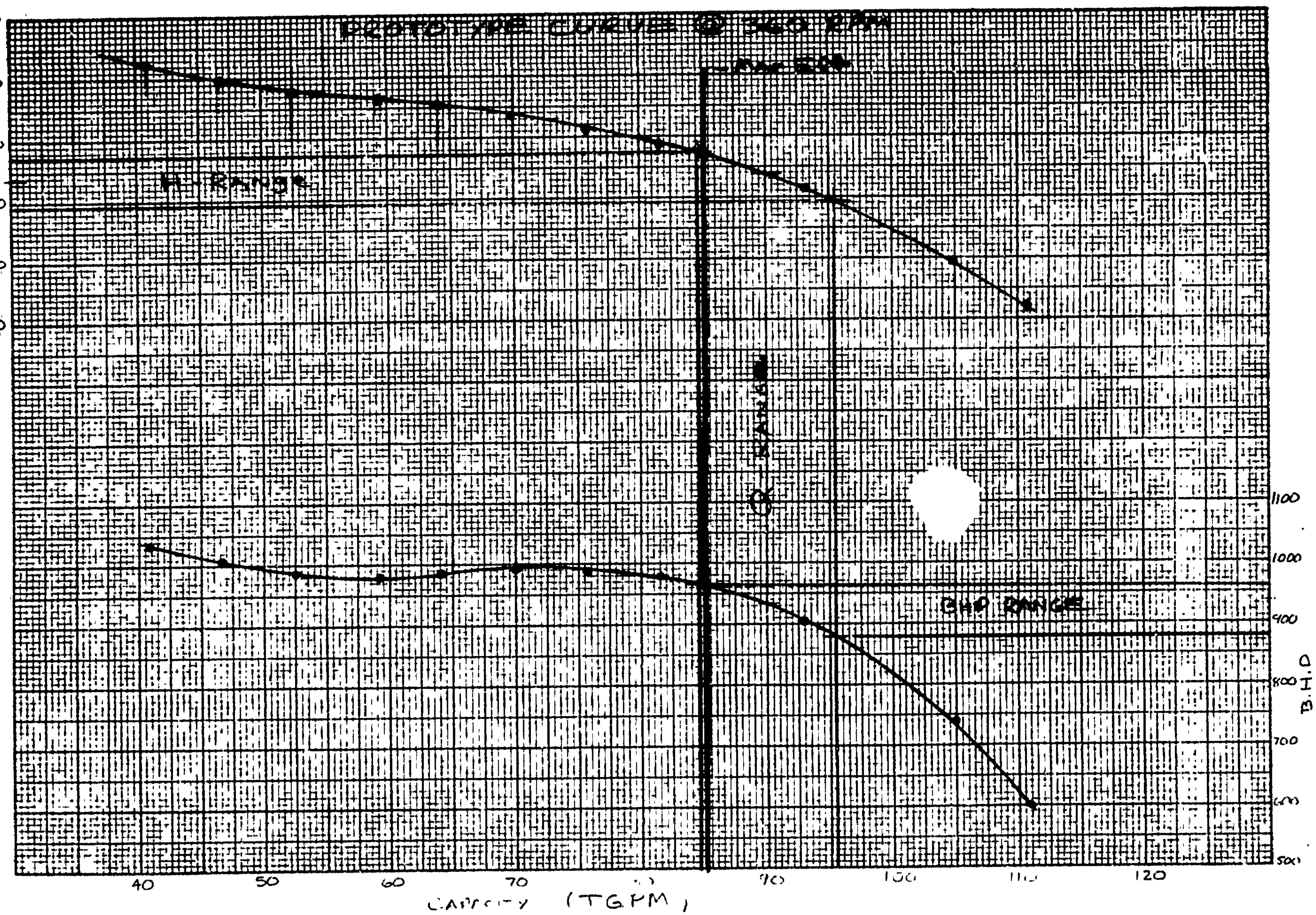
12. SPECIFIC SPEED

$$N_s = \frac{RPM\sqrt{G.P.M.}}{H^{.75}} = \frac{360\sqrt{90,000}}{(34)^{.75}} = 7670$$

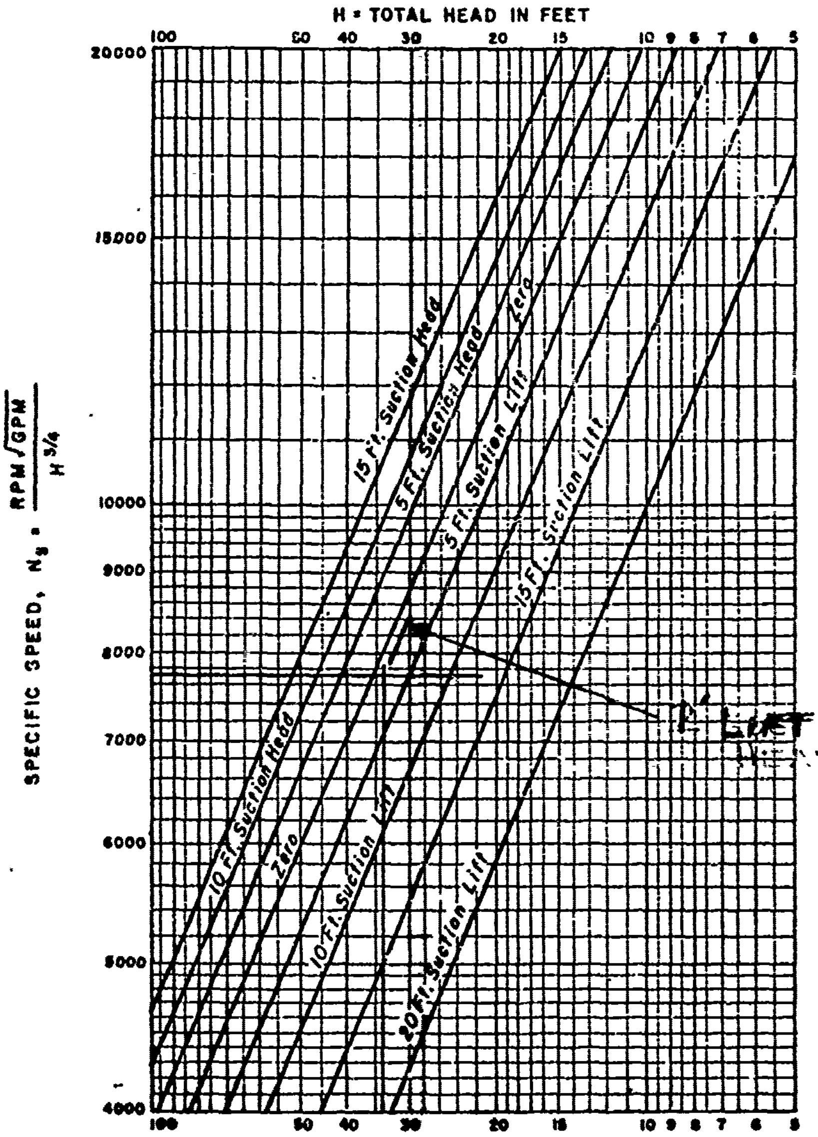
ABOUT 1' SUCTION LIFT

P137

SHEET 7 OF 8



SHEET 8 OF 8 P 138

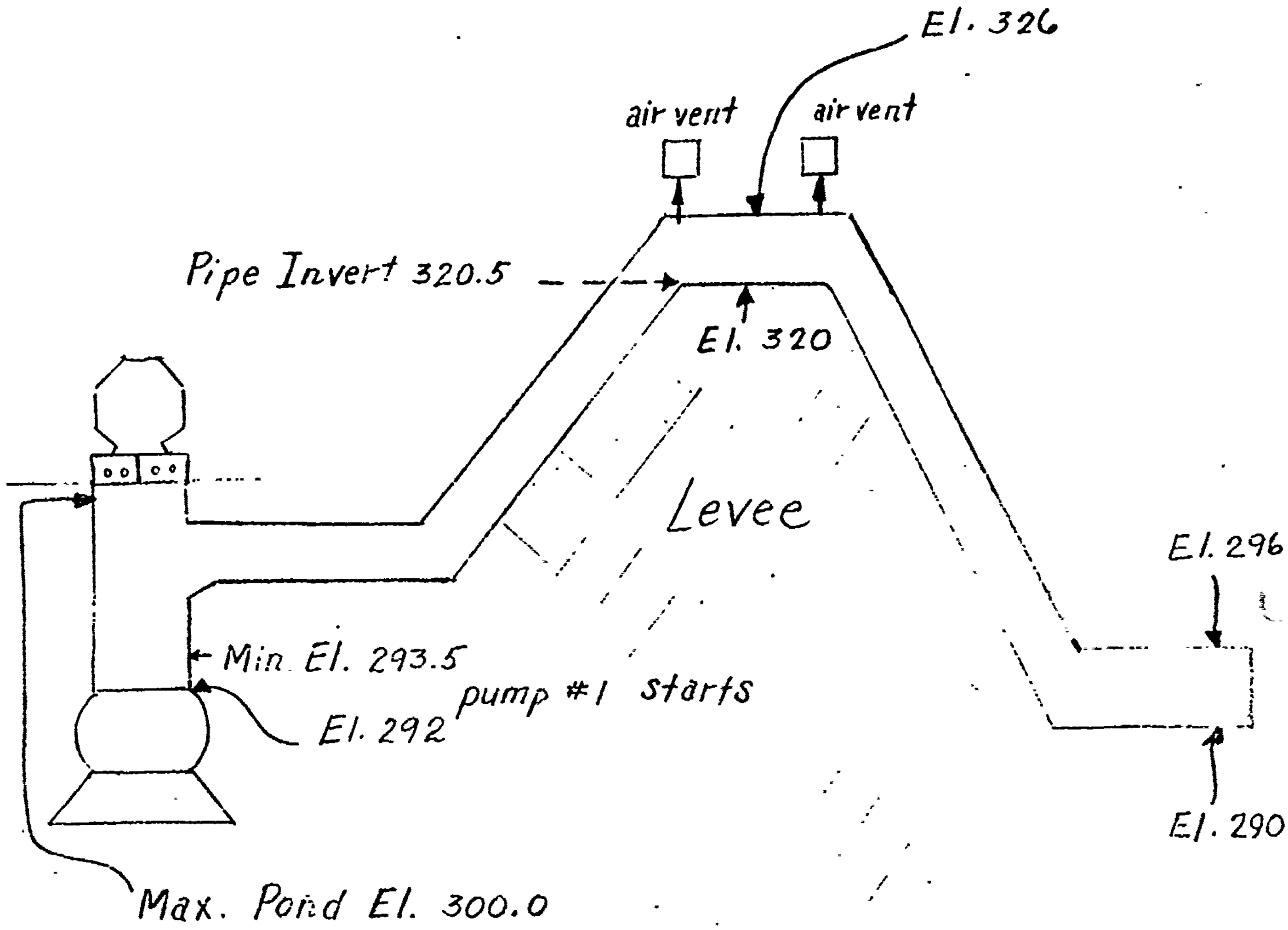


HYDRAULIC INSTITUTE UPPER LIMITS OF SPECIFIC SPEEDS FOR SINGLE-SUCTION PROPELLER AND MIXED-FLOW PUMPS

PLATE NO. 16

BY ____ DATE ____	SUBJECT Bernville Local Protection Pump Station	SHEET NO. 1 OF 12
CHKD. BY ____ DATE ____		JOB NO. ____
		p139

Calculation No. 20 based on Curve Plate 20



4 pumps plus sewage and seepage pumps, over levee discharge

Total 360,000 gpm at min. pool elevation 800 cfs.

BY ______ DATE ______ SUBJECT Bernville Local Protection Pump Station SHEET NO. 2 OF 12
CHKD. BY ______ DATE ______ JOB NO. ______
P 140

Static head 28.5 ft. to invert of pipe over levee

Discharge line $= \left(\frac{4 \times 269.6}{10\pi}\right)^{1/2} = 5.85$ ft. $= 70.3''$

Use 72" dia.

90,000 gpm; 7.09 ft./sec.; .78 ft. Vel. hd.; .277 ft. hd./100 ft.

.78 ft. Vel. head
.559 ft. frict. head

4 elbows (45°) @ $K = .45$

$h = [.0155 (7.09)^2 (.45)] \times 4$ elbows $= 1.4$ ft.

1.4 ft. elbow frict. head
6.0 ft. for head of pipe over levee above invert
28.5 ft. static head

37.23 ft. TDH

Use Plate No. 20, 21" model w/ TDH of 37.23 ft.

BY ____ DATE ____	SUBJECT BERNVILLE LOCAL PROTECTION PUMP STATION	SHEET NO. 3 OF 12
CHKD. BY ____ DATE ____		JOB NO. ____ p14'

PLATE No 20

95,000 gpm ADJUSTED PROTOTYPE FLOW

1. T.D.H. = 37.23 ft.

   HEAD PER STAGE = 18.61 ft.

2. DETERMINE FLOW PER PLATE 20

   $Q_m = 16,400$ gpm

3. DETERMINE PUMP DIAMETER

   $D_p = D_m\left(\frac{Q_p}{Q_m}\right)^{1/2} = 21\left(\frac{95,000}{16,400}\right)^{1/2} = 50.54''$

   USE 54" PUMP

4. NEW FLOW CAPACITY

   $Q_m = Q_p\left(\frac{D_m}{D_p}\right)^2 = 95,000\left(\frac{21}{54}\right)^2 = 14,367.3$ gpm

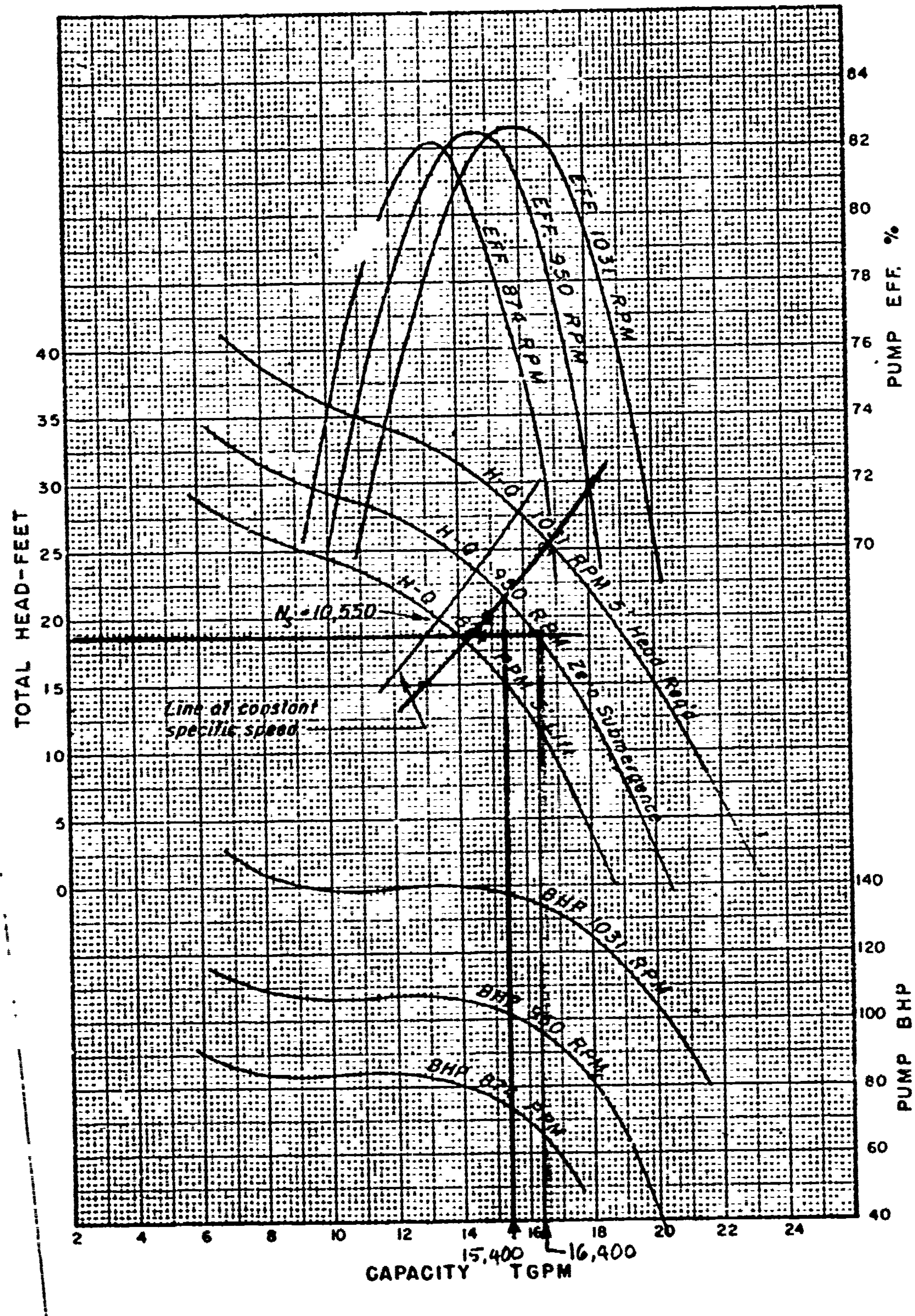
5. LINE OF CONSTANT SPECIFIC SPEED

   $Q_x = Q_c\left(\frac{H_x}{H_c}\right)^{1/2} = 14,367.3\left(\frac{H_x}{18.61}\right)^{1/2}$

H_x	Q_x
15	12,898.7
20	14,894.2
25	16,6[illegible].2
30	18,241.6
35	19,703.1

6. MODEL SPEED

   $N_c = N_x\left(\frac{Q_c}{Q_x}\right) = 950\left(\frac{14,3[illegible]}{15,400}\right) = [illegible].3$ RPM



21" MIXED-FLOW MODEL PUMP PERFORMANCE CURVES

PLATE NO. 20

BY .... DATE .... SUBJECT BERNVILLE LOCAL PROTECTION PUMP STATION SHEET NO. 5 OF 12

CHKD. BY .... DATE .... JOB NO. ....

7 NEW MODEL PLOT

$Q_c = Q_x\left(\frac{N_c}{N_x}\right) = Q_x\left(\frac{886.3}{950}\right) = .93\,Q_x$ SEE FINAL

$H_c = H_x\left(\frac{N_c}{N_x}\right)^2 = (.93)^2 H_x = .87\,H_x$ CALCULATIONS

$P_c = P_x\left(\frac{N_c}{N_x}\right)^3 = (.93)^3 P_x = .81\,P_x$

8 PLOT PROTOTYPE CURVE

$H_p = H_m$

$Q_p = Q_m\left(\frac{D_p}{D_m}\right)^2 = Q_m\left(\frac{54}{21}\right)^2 = 6.61\,Q_m$ " "

$P_p = P_m\left(\frac{D_p}{D_m}\right)^2 = P_m\left(\frac{54}{21}\right)^2 = 6.61\,P_m$

9 PROTOTYPE SPEED

$N_p = N_m\left(\frac{D_m}{D_p}\right) = 950\left(\frac{21}{54}\right) = 369.4$ RPM

10 SYNCHRONOUS PROTOTYPE CURVE @ 360 RPM

$Q_x = Q_c\left(\frac{N_x}{N_c}\right) = Q_c\left(\frac{360}{370}\right) = .97\,Q_c$

$H_x = H_c\left(\frac{N_x}{N_c}\right)^2 = H_c\,(.97)^2 = .95\,H_c$

$P_x = P_c\left(\frac{N_x}{N_c}\right)^3 = P_c\,(.97)^3 = .92\,P_c$

11 FINAL CALCULATIONS

$Q_{x1} = Q_{xi}\,(.97)(6.61)(.93) = 5.96\,Q_{xi}$

$H_{x1} = H_{xi}\,(.95)(.87)(2) = 1.65\,H_{xi}$

$P_{x1} = P_{xi}\,(.92)(6.61)(.81)(2) = 9.85\,P_{xi}$

BY______________ DATE__________ SUBJECT BERNVILLE LOCAL PROTECTION PUMP STATION SHEET NO. 6 OF 12

CHKD. BY________ DATE__________ JOB NO. ________ ~~φ144~~

VALUES FROM PLATE 20 ZERO SUBMERGENCE CURVE			VALUES FOR PROTOTYPE @ 360 RPM SYNCH.		
Q	H	P	Q	H	P
7000	33.1	112.0	41720	54.6	1103.2
8000	31.5	109.0	47680	51.9	1073.6
9000	30.3	107.0	53640	50.0	1053.9
10000	29.4	106.0	59600	48.5	1044.1
11000	28.6	106.5	65,560	47.2	1049.0
12000	27.6	107.5	71,720	45.5	1059.9
13000	26.3	107.0	77,480	43.4	1053.9
14000	24.6	106.0	83,440	40.6	1044.1
16000	19.8	98.0	95,360	32.7	955.3
[illegible]	12.5	80.5	107,280	20.6	798.0
19000	7.6	65.0	113,240	12.5	640.2

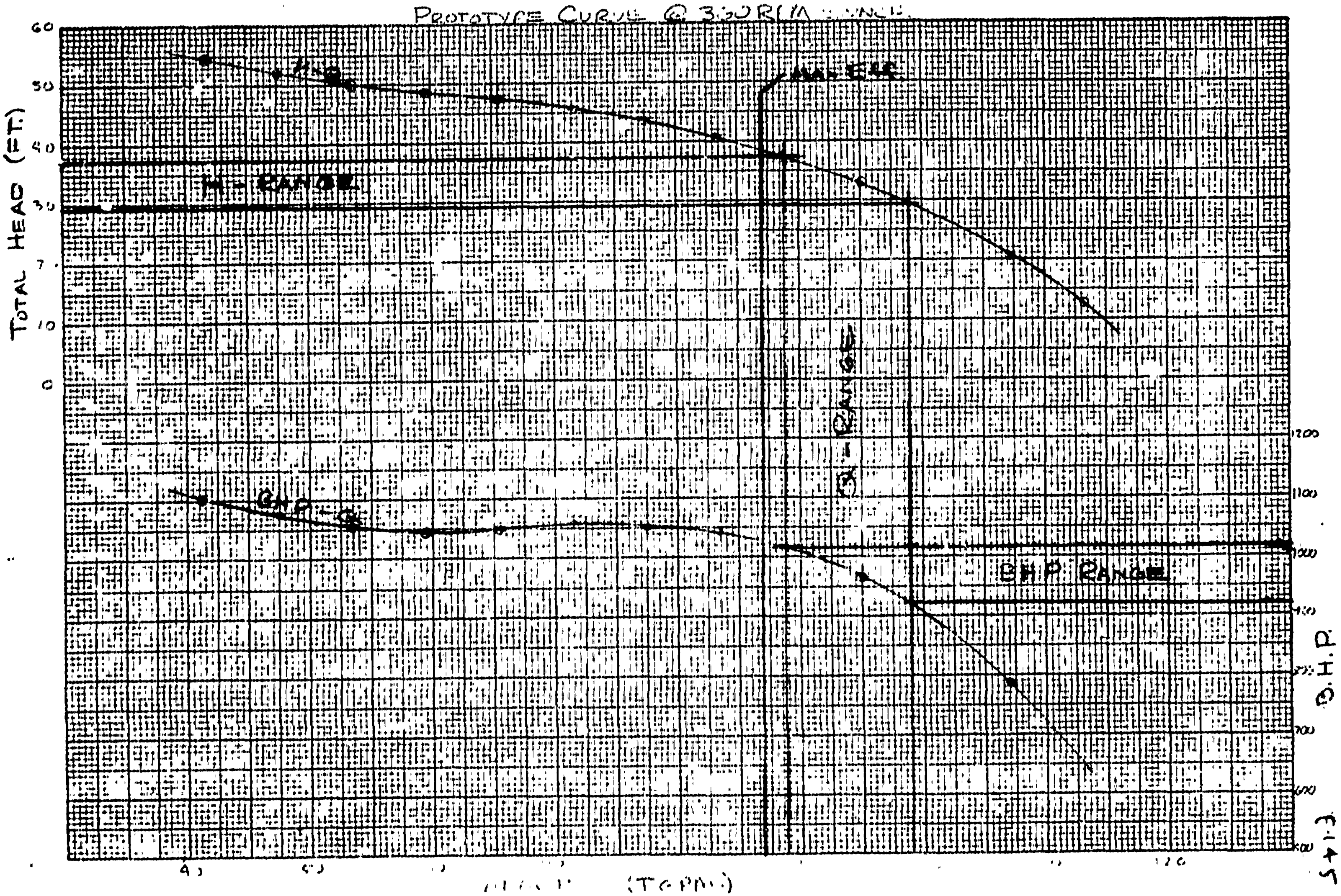
MAX. EFF. 14,600 MAX. EFF. 87,016

12 SPECIFIC SPEED

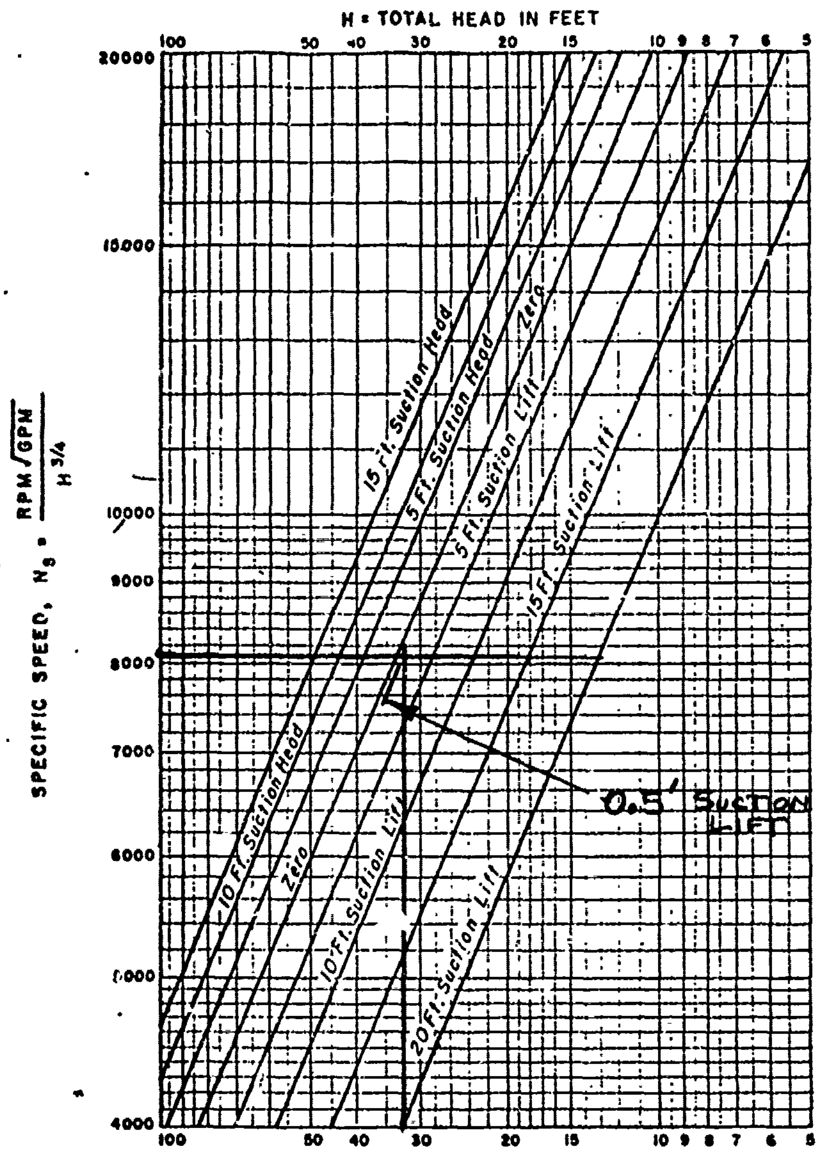
$$N_s = \frac{RPM\sqrt{GPM}}{H^{3/4}} = \frac{360\sqrt{95,360}}{(32.7)^{3/4}} = 8129.7$$

ABOUT 1/2' SUCTION LIFT

SHEET 7 OF 12



F-145



HYDRAULIC INSTITUTE UPPER LIMITS OF SPECIFIC SPEEDS FOR SINGLE-SUCTION PROPELLER AND MIXED-FLOW PUMPS

PLATE NO. 16

BY	DATE	SUBJECT BERNVILLE LOCAL	SHEET NO. 9 OF 12
CHKD. BY	DATE	PROTECTION PUMP STATION	JOB NO.
			P147

FLOW, HORSEPOWER AND SPECIFIC SPEED CALCULATIONS AT EXTREMELY LOW T.D.H.

1. CALCULATIONS (FROM 37.23 ft. T.D.H. CALCULATIONS)

$Q_{xf} = 5.96\ Q_{xi}$

$H_{xf} = 1.65\ H_{xi}$

$P_{xf} = 9.85\ P_{xi}$

LOWER LIMIT VALUES FROM P.20 ZERO SUB. CURVE			VALUES @ 360 RPM PROTOTYPE (SYNCH.)		
Q	H	P	Q	H	P
17,800	13.4	83.0	106,088	22.1	817.5
18,000	12.7	80.5	107,280	20.9	792.9
18200	11.7	78.0	108,472	19.3	768.3
18400	10.7	74.5	109,664	17.6	733.8
18600	9.7	71.5	110,856	16.0	704.3
18800	8.6	68.0	112,049	14.2	669.8
19000	7.6	65.0	113,240	12.5	640.2
19200	6.6	61.0	114,432	10.9	600.8
20000*	2.5*	41.0*	119,200	4.1	403.8

* VALUES INTERPOLATED

2. Specific Speed at Low TDH Values

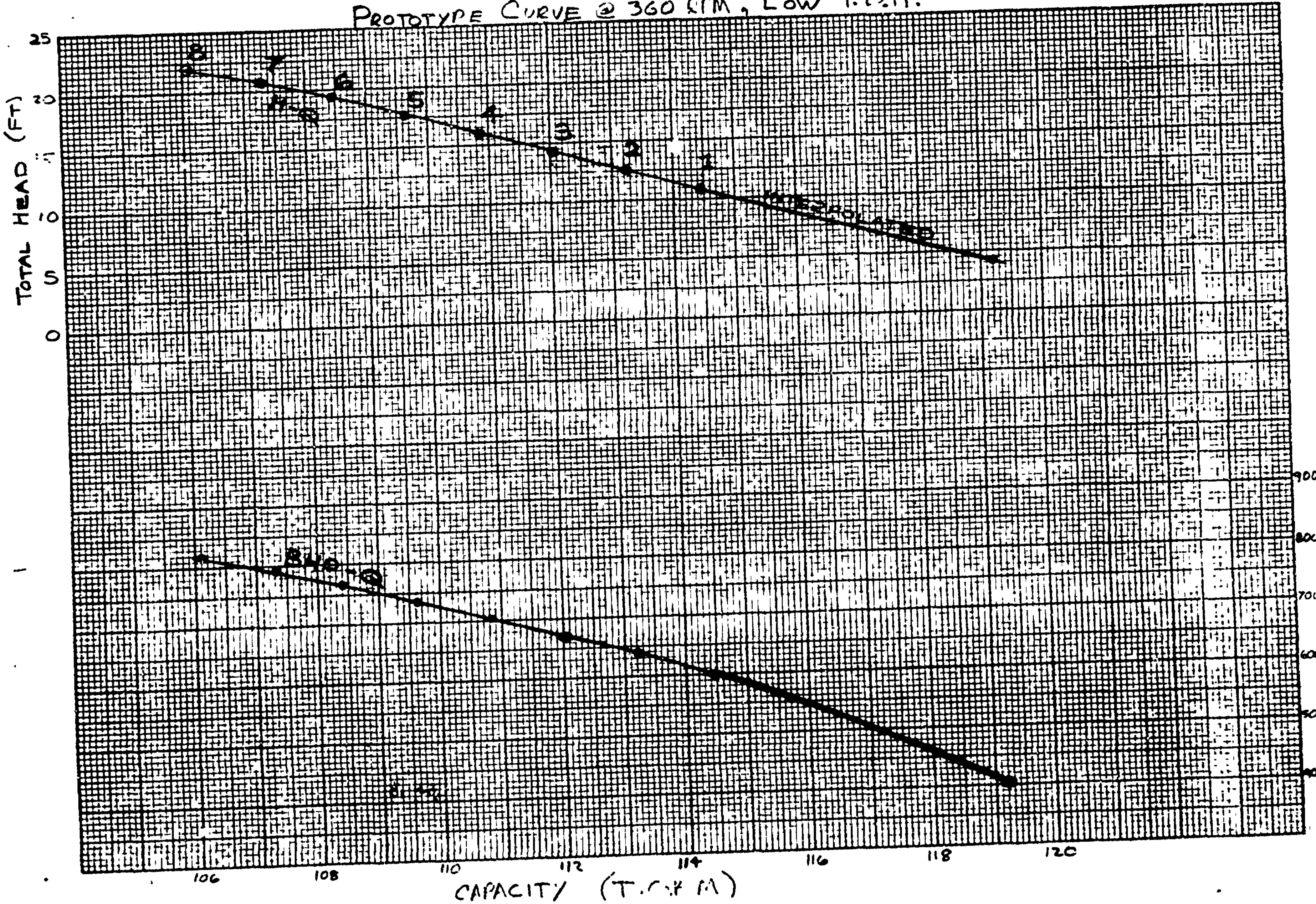
$$N_s = \frac{RPM\sqrt{GPM}}{H^{.75}} \quad \text{WHERE } RPM = 360$$

Point No (see graph)	T.D.H.	Q (gpm)	N_s	Remarks
1	10.9	114432	20.300.5	± 3' Suction Head
2	12.5	113,240	18 223.0	± 3' Suction Head
3	14.2	112,048	16,473.6	± 3' Suction Head
4	16.0	110,856	14,982.8	± 3' Suction Head
5	17.6	109,664	13,873.9	± 2' Suction Head
6	19.3	108,472	12,876.4	± 2' Suction Head
7	20.7	107,280	12,062.9	± 2' Suction Head
8	22.1	106,088	11 503.8	± 1' Suction Head

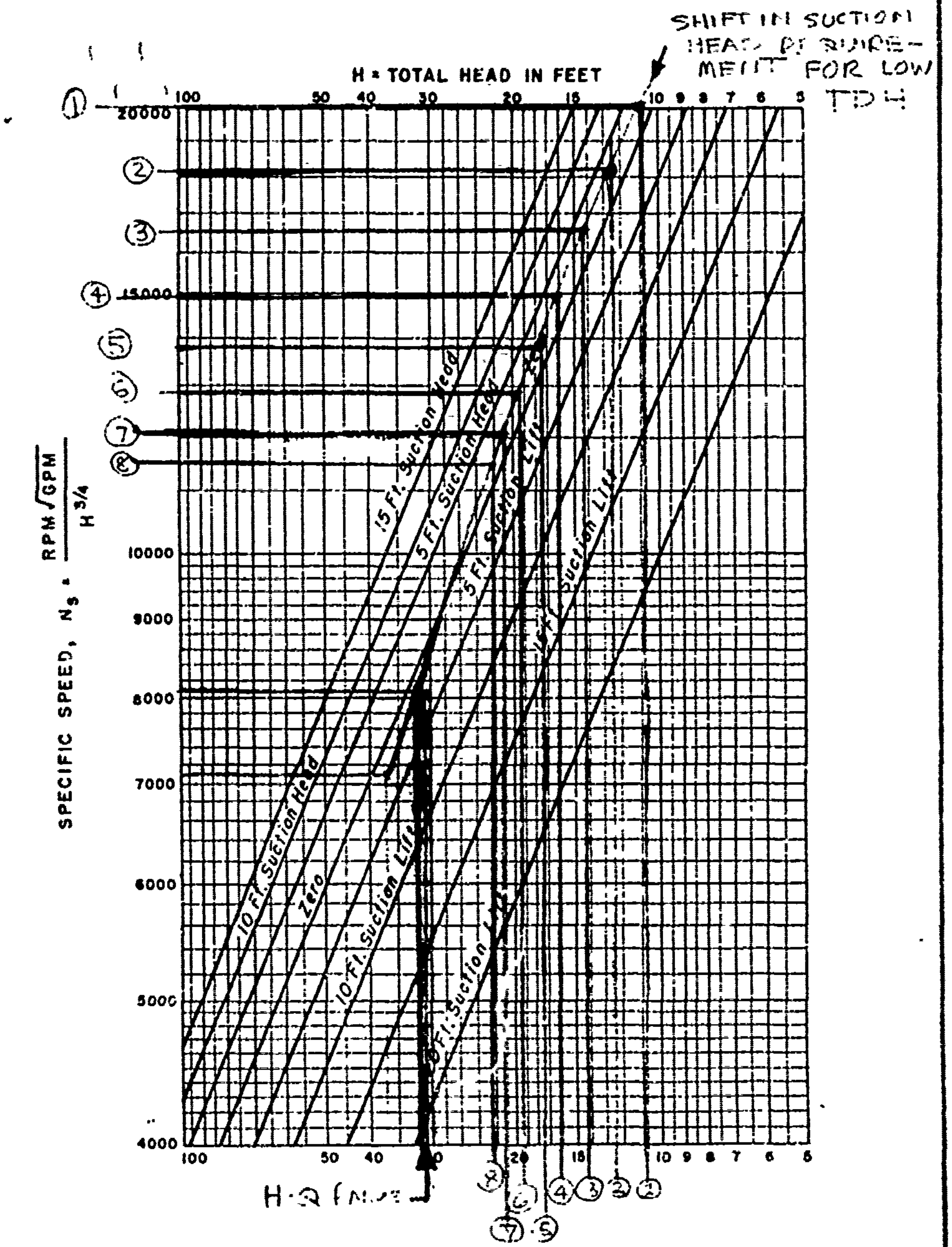
SHEET 11 OF 12

K•E 10 X 10 TO ½ INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

PROTOTYPE CURVE @ 360 RPM, LOW T.D.H.



SHEET 12 OF 12 P.150



HYDRAULIC INSTITUTE UPPER LIMITS OF SPECIFIC SPEEDS FOR SINGLE-SUCTION PROPELLER AND MIXED-FLOW PUMPS

PLATE NO. 16

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PENNSYLVANIA
BLUE MARSH LAKE

DESIGN MEMORANDUM NO. 13
BERNVILLE PROTECTIVE WORKS

APPENDIX D
PERTINENT CORRESPONDENCE

NAPEN-D Dated 14 June 1974

Mr. Robert Grant
Metropolitan Edison Company
P. O. Box 542
Reading, PA 19603

Dear Mr. Grant:

We are currently working on the design of a pumping station for the Flood Protection Works at Bernville Pa. in connection with our Blue Marsh Lake Project. Preliminary calculations indicate that the total connected pumping load will be in the range of 3000-3500 horsepower.

Depending on the results of our economic studies, this total load will be split up among 3, 5, or 7 individual 2300 volt pumps. Connected load of station auxilliaries is estimated at 150 KVA with a maximum demand of 50 KVA.

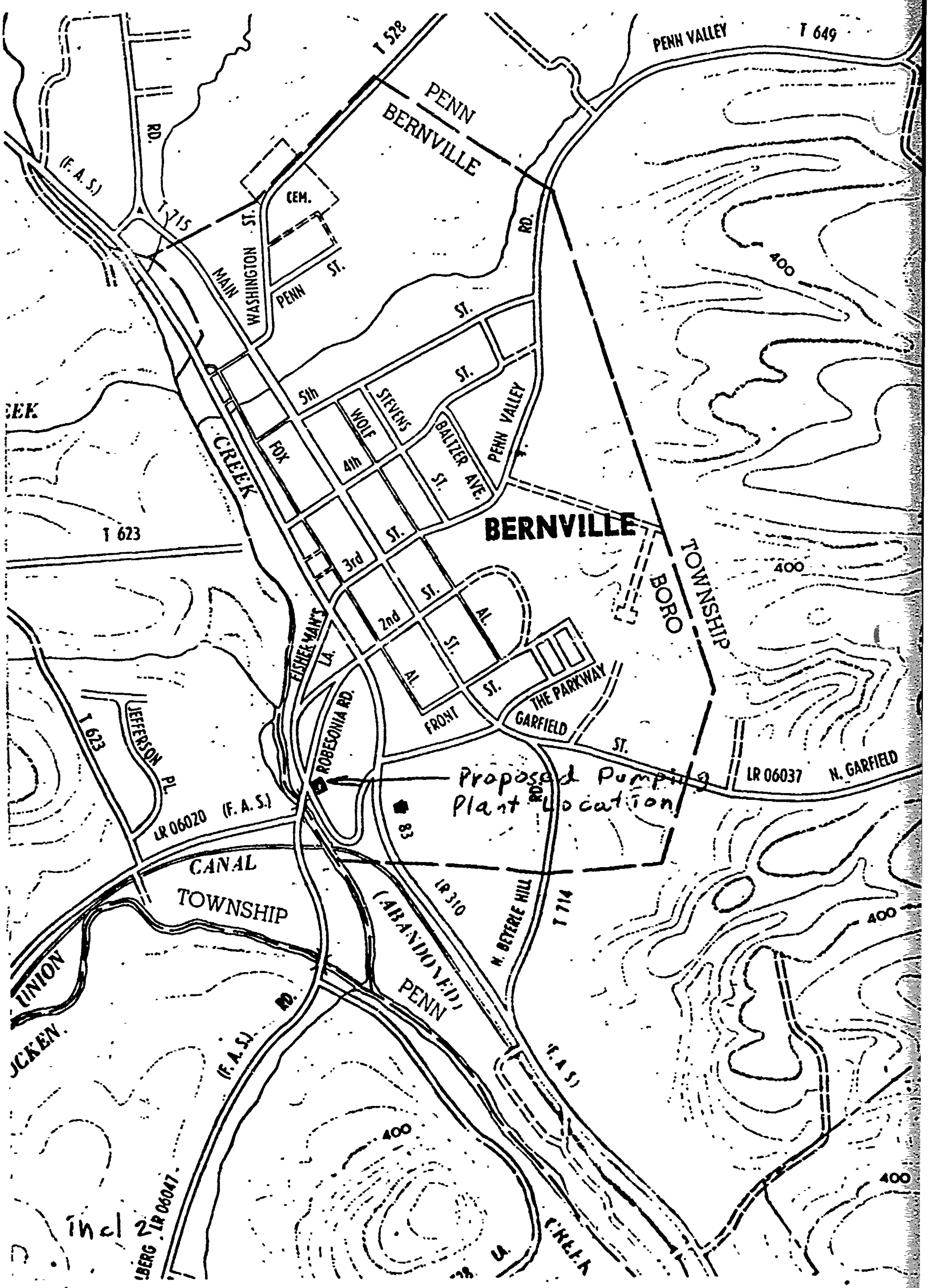
We ask that you furnish us with the information requested on the inclosed list in order that we can continue our design studies and prepare recommendations to our higher authority. A plan of the Bernville area showing the approximate location of the pumping plant is also inclosed. Please refer any questions you may have to Mr. Frank Braun of this office at (215) 597-4751.

Your assistance in this matter will be greatly appreciated.

Sincerely yours,

2 Incl
As Stated

WORTH D. PHILLIPS
Chief, Engineering Division



T 528
PENN VALLEY
T 649
PENN
BERNVILLE
RD.
(F. A. S.)
T 715
CEM.
MAIN
WASHINGTON
ST.
PENN
ST.
RD.
400
ST.
5th
ST.
STEVENS
WOLF
BALTZER AVE.
PENN VALLEY
FOX
4th
ST.
CREEK
T 623
BERNVILLE
TOWNSHIP
BORO
3rd
ST.
400
2nd
ST.
AL.
ST.
FISHERMAN'S LA.
AL.
ROBESONIA RD.
FRONT
ST.
THE PARKWAY
GARFIELD
ST.
LR 06037
N. GARFIELD
T 623
JEFFERSON PL.
LR 06020 (F. A. S.)
83
RD.
Proposed Pumping Plant Location
CANAL
TOWNSHIP
(ABANDONED)
LR 310
N. BEYERLE HILL
T 714
400
UNION
PENN
RD.
(F. A. S.)
(F. A. S.)
400
400
LR 06047
LA.
CREEK

Incl 2

INFORMATION REQUESTED FROM
METROPOLITAN EDISON CO.
FOR DESIGN OF BERNVILLE PUMPING STATION

1. Our design guides recommend separate services for the main pump system and the station auxilliaries. This allows the high capacity service for the pumps, with it's related transformers and switchgear, to be normally de-energized. We would like to have your views on the suitability of such an arrangement and it's affect on the cost of the service installation.

2. Is an adequate source of power available? If not, how and from where could one be made available?

3. What restrictions, if any, would the prospective power source have, such as maximum permissible motor inrush current, requirement for reduced voltage starting, maximum power available, voltage regulation characteristics and available short circuit current?

4. What is the capacity and location of transmission lines, distribution lines and substations from which service can be taken?

5. Please provide historic data on power outages, particularly during emergencies caused by floods or other storm effects for the prospective power source, including substations distribution lines, transmission lines and power plants.

6. Please furnish data on the number, size, type and location of generating facilities and inter-connections to other systems which are part of the power grid that will provide service.

7. What will be the length, construction and location of the supply line needed to connect our pump station to your existing facilities?

8. Will it be possible or advisable from the standpoint of reliability to have two independent sources of power for the main pumping system? If so, where would the point of connection to such an independent source be located? What type switching would be used?

9. Please furnish an estimate of the total cost to us of service installation and a list of any labor materials or equipment which we will have to furnish.

Incl 1

What differences in installation cost and rate structure would there be if we own and maintain the transformers and/or primary switching and protective equipment need at the pump station instead of you owning them?

11. What effect, if any, will the number and size of pumps have on the cost of service construction?

12. What will be the effect on service construction cost, of having two independent sources?

0310-0500-0200

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
1713-41 Lehigh Street
P.O. Box 1379
Allentown, Pennsylvania 18105
July 23, 1974

LY REFER TO

:s County
: Marsh Dam Project
Army Corps of Engineers
310 Relocation

Mr. Worth D. Phillips
Chief, Engineering Division
Department of the Army
Philadelphia District, Corps of Engineers
Custom House - Second and Chestnut Streets
Philadelphia, Pennsylvania 19106
Attention: Mr. Brian Heverin

Dear Mr. Phillips:

We have reviewed your July 19th submission of the revised vertical geometry for the relocation of a section of L.R. 310 in Bernville, Berks County, and have found it to be in conformance with our design standards for Class 2 highways. Your previous submission of horizontal geometry for this relocation, which was dated June 19, 1974, was also adequately designed.

We therefore issue tentative line and grade approval for the relocation of L.R. 310. Final line and grade approval will be granted at the Design Field View (Step 9 of Design Location Study Stage).

If you have any questions or require additional information on this project, please contact the undersigned.

Very truly yours,

A. V. Cesare, P.E.
District Engineer
Engineering District 5-0

Robert L. Jones

By: R. L. Jones, P.E.
District Locations Engineer

JDW/pm

D-5

METROPOLITAN EDISON COMPANY SUBSIDIARY OF GENERAL ... CORPORATION

POST OFFICE BOX 542 READING, PENNSYLVANIA 19603 TELEPHONE 215 – 923-3601

October 24, 1974

Mr. Frank Braun
Department of the Army
Philadelphia District -
Corps of Engineers
Custom House 2-D & Chestnut Sts.
Philadelphia, Pennsylvania 19106

Dear Mr. Braun:

Re: Flood Protection Works
Blue Marsh Lake Project
Bernville, Pennsylvania

This letter is in reply to Mr. W. D. Phillips' communication dated June 14, 1974, in which he inquired as to the availability of 2300 volt service for several 1000 HP pumps near Bernville, Pennsylvania. I hope that the following will provide you with the necessary information.

Met-Ed is unable to provide a 2300 volt service. It will be necessary for you to provide the required transformation from our 13.2 KV or 69 KV primary. Consequently, a single primary meter service is recommended.

13.2 KV: We can provide a single 13.2 KV service from our Bernville Substation with the qualification that a 50% reduced voltage starter must be installed on each of the 1000 HP motors and that none of the motors would start simultaneously. The percent voltage drop experienced, assuming six times full load current on starting, will be 2.47% on Met-Ed's 13.2 system. Met-Ed's policy has been to limit voltage fluctuation to 2.5%. The minimum contract billing demand shall be 300 KW. This will cost the Corps of Engineers and the Blue Marsh Project approximately $23,000.

A second or back up 13.2 KV service can be made available at an additional $200,000. Because of the longer distance from the service, the voltage drop is calculated at 3.9% with the same 50% reduced voltage starter on each of the large motors. However, since this would be the alternate feed, we feel that we will be able to tolerate

-cont'd-

this higher than desireable impact on our system. The minimum contract billing will be based on a 600 KW demand.

69 KV: A 69 KV primary can be provided with no motor starting restrictions. A dual feed on a single pole line, across country construction, will cost you approximately $300,000. A dual feed on separate pole lines has been estimated at $350,000. The contract minimum will be based on a 600 KW demand.

A single feed 69 KV can be made available at an approximate cost of $110,000. This does not include tree trimming. This will also carry a contract minimum of 600 KW demand.

In every situation you must provide a termination point and a breaker on the high side. Reliability on our existing 13.2 KV line is good. During the past six years, there have been a total of nine interruptions to the main line, with the longest being seven seconds.

As soon as you decide which direction you want to proceed with, I suggest you plan on a meeting with us to review the technical aspects and our mutual interests.

It's important to keep in mind that the cost values mentioned above are strictly rough estimates. At a time when a definite decision is made as to which service you will require, we will then calculate a more accurate estimate.

If you need any additional information, please call me.

Sincerely,

R J Grant Sr

Robert J. Grant, Sr.
Administrator-Municipal Svcs.

RJG:jolf

METROPOLITAN EDISON COMPANY SUBSIDIARY OF GENERAL PUBLIC UTILITIES CORPORATION

POST OFFICE BOX 542 READING, PENNSYLVANIA 19603 TELEPHONE 215 – 929-3601

November 18, 1974

Mr. Frank Braun
Department of Army
Philadelphia District
Corps of Engineers
Custom House - 2nd & Chestnut Sts.
Philadelphia, Pennsylvania 19106

Dear Frank:

Re: Flood Protection Works
Blue Marsh Lake Project
Bernville, Pa.

Enclosed is a summary of the interruptions on our 69 KV line at Bernville.

If you have any questions, please give me a call.

Sincerely,

Robert J. Grant, Sr.
Administrator-Municipal Svcs.

RJG:jlf

cc: Lt. Charles Atkins
Blue Marsh Project Office

Enclosure

OUTAGE HISTORY - 10 YEARS

835 LINE - BERN CHURCH - BERNVILLE

Date	Duration	Cause
8/8/65	5 sec	Electrical Storm
9/24/65	5 sec	Electrical Storm
7/19/66	5 sec	Electrical Storm
8/16/66	5 sec	Electrical Storm
6/17/67	1/2 min	Electrical Storm
6/22/67	5 sec	Electrical Storm
8/8/67	5 sec	Electrical Storm
1/14/68	5 sec	Ice Storm
6/18/70	5 sec	Electrical Storm
7/16/72	10 sec	Electrical Storm, 2-5 sec interupt.
11/24/72	1 hr 29 min	Faulty potential device at Bern Church. Did not interrupt customers. (On 13.2 KV line)

No interruptions during 1969, 1971, 1973, and 1974, to date.

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NAPEN-D	Public Meeting with Officials of Bernville Boro on proposed plans for Bernville Protective Works, Blue Marsh Lake, PA.

TO Memo for R & R File FROM T. B. Heverin DATE 7 Nov 74 CMT 1

HEVERIN/my/4756

1. DATE: 6 November 1974

2. PLACE: Bernville Vol. Fire Co. Firehouse, 2nd Floor.

3. PERSONNEL ATTENDING:

Mr. S. H. Clay, Mayor, Bernville Boro
Mr. E. Thomas Sheet, President, Bernville Boro Council
Mr. David J. Spang, Solicitor, Bernville Boro Council
Mr. Paul N. Sheetz, Secretary, Bernville Boro Council
Mr. G. H. Bashor, Bernville Boro Council
Mr. E. E. Graeff, Bernville Boro Council
Mr. Ronald Himmelberger, Bernville Boro Council
Mr. Howard D. Madeine, Bernville Boro Council
Mr. Gerard J. Moyer, Frankhousen Assoc., Inc., Boro Engr.
Mr. M. G. Delong, Chairman, Bernville Sewer Authority
Mr. Thomas R. Smith, Gilbert Associates Inc., Sewer Auth. Engr.
Mr. R. A. Kirsling, Representative, St. Thomas Church

(Note: A number of individuals above also represented the school board and a few individual residents of Bernville were also present:

Mr. V. L. Calvarese, Chief, General Design Section
Mr. T. B. Heverin, Chief, Recreation & Relocation Section
Mr. J. Kane, Chief Soils Design Section
Cpt. C. P. Adkins, Asst. Res. Engr. Blue Marsh Lake
Mr. C. E. Brown, Real Estate Project Office, Blue Marsh Lake

4. PROGRAM DISCUSSION:

a. The Meeting was called to order by Mayor Clay and local officals and representatives of the Corps introduced themselves.

b. Mr. Heverin presented a ½ hour briefing using color-highlighted drawings prepared as part of DM #13 Bernville Protective Works. A drawing showing the General Plan of the Protective Works (DM #13 Plate 3) was handed out to officials.

c. The briefing covered the following major items.

(1) Location and size of Levee and relocated Northkill Creek.

(2) Ponding Area
Relocation of Roads LR310, LR06017, T-715 and boro streets.

(3) Effected utilities especially sewer system lines and manholes, sewerage outfall and protection of sewerage plant.

(4) Location, size, architectural treatment, and operation of pumping station.

(5) Location and size of flanking levee, and borrow area.

(6) Effect of protective works in vicinity of school

(7) Effect of protective works in vicinity of St. Thomas Church.

(8) Lands required for protection including construction easements.

(9) Detour of traffic over 2nd Street and Main Sts. and temporary runaround in vicinity of school for one construction season.

(10) Environmental enhancement and landscaping.

(11) Current preliminary construction schedule.

d. The meeting was opened for approximately one hour for questions from the floor.

e. Boro officials made the following requests:

(1) Repair potholes, control dust and plow snow on detour route.

(2) Repave detour route on completion of construction since the boro streets are not designed to carry the high volume of truck and car traffic now on LR310.

(3) Request that Fox Alley be carried over culvert in vicinity of Church on Washington St.

(4) Requested guardrail or safety fencing along runaround in vicinity of school.

f. The local officials are generally in agreement with the proposed protective works plans as presented.

g. The color drawings will be displayed in the Project Real Estate Office and Resident Engineer's Office for inspection by interested individuals.

h. Preliminary drawing showing project effect on sewerage treatment plant and system was given to Sewage Authority.

NAPEN-D SUBJECT: Public meeting with Officials of Bernville Boro on proposed plans for Bernville Protective Works, Blue Marsh Lake, PA.

5. FOLLOW UP ACTION REQUIRED: Currently, a letter to Mayor Clay explaining the following items which were raised during the question-and-answer period is being prepared.

a. The reliability of power supply for pumping station.

b. The ability of trash rack at pumping station to handle trash and debris buildup.

Thomas B. Heverin
THOMAS B. HEVERIN
Chief, Recreation & Relocation Section

D-12

SCHUYLKILL RIVER BASIN
TULPEHOCKEN CREEK, PENNSYLVANIA
BLUE MARSH LAKE

DESIGN MEMORANDUM NO. 13
BERNVILLE PROTECTIVE WORKS

APPENDIX E
ATTORNEY'S REPORT

ATTORNEY'S REPORT

This report is prepared in accordance with Section 73-204 of ER 1180-1-1. Its purpose is to show the obligation, if any, of the United States to alter, relocate or replace any or all of the facilities of the various utility companies and municipalities, which may be affected by the construction and/or operation of the Bernville Protective Works.

The Blue Marsh Lake Project is authorized under the Flood Control Act of 1962, Public Law 87-874 (House Document No. 522, 87th Congress, 2d Session).

The relocations, alterations and/or abandonments proposed in this Design Memorandum are necessitated solely by the construction and operation of the Blue Marsh Lake Project; therefore, there is no other responsibility for the relocations, alterations and/or abandonments.

FACTS

The lands within the Project are acquired or are being acquired subject to existing easements for public roads and utilities. Where these facilities interfere with the operations of the project, it is necessary to alter them in some way as to minimize the interference. This is ordinarily accomplished by means of a relocation contract. "Where a replacement is necessary, a substitute facility will be provided which will as nearly as practicable serve the owner in the same manner and reasonably as well as does the existing facility. Such facilities usually will be relocated outside the project limits except when they can be feasibly adjusted or protected within the project limits so as not to interfere with the construction, maintenance and operation of the project."

It is necessary therefore to ascertain the ownership of the facilities as well as the compensable interest and authority of the various owners of the facilities that will be affected by the Project.

DISCUSSION

The construction of the Bernville Protective Works will affect facilities owned by the Pennsylvania Department of Transportation, Penn Township, Bernville Borough, Metropolitan Edison Company, Bethel and Mt. Aetna Telephone and Telegraph Company, and Heidelberg, Incorporated. The affected facilities of each owner concerned will be discussed separately.

PENNSYLVANIA DEPARTMENT OF TRANSPORTATION

LEGISLATIVE ROUTE 310, PENNSYLVANIA ROUTE 183

This Class 2 highway is the principal north-south highway in the vicinity of the project. West of Bernville, the levee paralleling the Northkill Creek will cover the existing Legislative Route 310 necessitating relocation. The most feasible relocation is on top of the levee along the existing horizontal alignment. Relocation to the west would be in the lake, and to the east through Bernville.

According to Title 36, Pennsylvania Statutes Annotated, Section 1234, Legislative Route 310 is part of the Pennsylvania Highway System, and therefore the Commonwealth of Pennsylvania must maintain this highway. The Department of Transportation, an agency of the Commonwealth of Pennsylvania, has a compensable interest in this highway.

LEGISLATIVE ROUTE 06017

Legislative Route 06017 intersects Legislative Route 310 just west of the Borough of Bernville in Penn Township. The relocation of Legislative Route 06017 will be at its intersection with Legislative Route 310 where it (Legislative Route 06017) will be ramped up to meet Legislative Route 310.

According to Title 36, Purdon's Pennsylvania Statutes Annotated, Sections 1738-1 and 1738-2, Legislative Route 06017 is a part of the Pennsylvania Highway System, and therefore the Commonwealth of Pennsylvania must maintain this highway. The Department of Transportation, an agency of the Commonwealth of Pennsylvania, has a compensable interest in this highway.

LEGISLATIVE ROUTE 06047

Legislative Route 06047 crosses the Northkill Creek and the proposed levee just upstream of the planned pumping station. This highway is to be relocated as indicated in Design Memorandum No. 11, Highway Relocations, previously submitted. The Attorney's Report for this highway relocation can be found in Design Memorandum No. 11.

COMMONWEALTH HIGHWAYS

All references to statutes hereinafter made except when noted is referenced to Purdon's Pennsylvania Statutes Annotated, Copyright 1961, as supplemented in 1974. The word "Secretary" refers to the Secretary of the State Highway Department.

Title 32, Forests, Waters and State Parks, Section 678.1 Grant of Easements and Rights to United States; Agreements Authorized - In any case where the United States Government, or any agency thereof, under the authority of an Act of Congress has heretofore commenced or finished, or shall hereinafter commence or finish, any work on or construction of a retarding dam, channel improvement or other flood control project in relation to any river, stream or creek in this Commonwealth, and the authorized representatives of the United States deem it necessary for the successful operation of said flood control project and for the safety of life and preservation of property to secure from the Commonwealth or any political subdivision thereof certain easements and rights in or relative to the highways, roads, streets and bridges thereof and the land bordering the same over which such governmental units may have control, the Commonwealth and the various political subdivisions thereof are hereby authorized to grant to the United States such easements and rights and to enter into agreements therewith as hereinafter provided.

Title 32, Section 678.2 Agreements May Be Entered Into; Rights and Easements Which May Be Granted - The Secretary of Highways, acting for the Commonwealth, the county commissioners of any county, the mayor of any city and the burgess of any borough, with the approval of the city or borough council and the commissioners or supervisors of any township, may, with the approval of the Water and Power Resources Board, enter into an agreement with, or execute a deed to, the United States or any agency thereof granting and conveying thereto the following perpetual rights and easements to be exercised, whenever in the judgment of the representatives of the United States it is necessary:

(1) To flood for temporary periods any highway, street, bridge, viaduct, or road or any portion thereof over which the Commonwealth or the political subdivision has control and which is designated in such agreement or deed. Such highways, streets, bridges, viaducts and roads shall continue to be maintained by the State or its local subdivisions.

(2) To enter upon said highways, streets, bridges and roads and the lands bordering the same over which the Commonwealth or the political subdivision has control to widen the aforesaid river, stream or creek through or along said lands, to erect structures, revetments and bank slopes upon said lands and to inspect, maintain and operate said structures, revetments and bank slopes.

(3) To relocate roads, streets, bridges, viaducts and other public works and improvements at the cost of the United States, the relocation of State highway routes may be made without regard to terminal or intermediate points mentioned in the law establishing such routes. Agreements may provide for abandonment of existing roads, streets, bridges, viaducts and public works and improvements, whether or not supplied by relocations.

Title 32, Section 666 Relocation, Abandonment and Vacation of Roads, Streets, and Bridges - The Department of Highways and municipalities may enter into agreements with the board, or Federal agencies with the approval of the board, to relocate roads, streets, bridges, and viaducts necessitated by the construction of any state or Federal flood control works and improvements; and may agree therein to construct new roads, streets, bridges, and viaducts, and pay the cost of the same, or any part thereof, from the Motor License Fund or municipal moneys without any charge or only part of the cost charged against the moneys in the General Fund Appropriations for Flood Control Projects. The board may consent in any such agreement to pay the whole or any part of the cost of constructing such relocated roads, streets, bridges, and viaducts from the moneys in the General Appropriations for Flood Control Projects. Such relocated roads, streets, bridges, and viaducts may be constructed by the Department of Highways or by contract let by said department or the municipality or by the board or by a Federal agency as may be agreed upon. Relocation of State highways shall be made by plans properly approved as is required by law for the relocation of State highway routes, and may be made without regard to terminal or intermediate points mentioned in the law establishing such routes. The portions of State highway routes supplied by such relocations may be abandoned by the Secretary of Highways in the manner provided by law, whereupon said abandoned portions of State highway routes shall revert to the authorities responsible for the maintenance of the public road or highway prior to its having been established as a State highway. Where any State highway route, or part thereof, shall become inundated by the waters of any flood control reservoir, or shall become unnecessary for public use and travel, or burdensome or dangerous due to the construction of any flood control reservoir, the Secretary of Highways with the approval of the Governor may abandon as a State Highway such State highway route, or part thereof. The Secretary of Highways may also at any time by and with the consent of the local authorities, by written order declare the portion or portions of road or roads so abandoned to be vacated and closed to public use and travel and no longer a public road, without limitation because of the length of the road to be vacated.

Title 32, Purdon's Statutes 659 to 662 authorizes the Water and Power Resources Board, Department of Forest and Water to accept conveyances from the United States of America for relocated highways.

Title 36 Highways, Section 670-210, Relocation, etc: Abandonment as State Highway; Vacation; set forth that the Secretary of the State Highway Department is empowered to change, alter, or establish the width, length, location, and grades of any highway . . . After the relocation is complete, the Secretary by notice to the local authorities shall abandon as a state highway route or vacate the section of highway between the termini of the relocation. Where the new route in the judgment of the Secretary takes the place of any portion of the old highway (such portion being less than two miles), the Secretary, if he determines that the

proposed abandonment is unnecessary for public use, may by written order declare such portion vacated. This law further provides for the Secretary to file a plan of the Order of Vacation, duly approved by the governor, in the County Office for the recording of deeds in which the highway is located.

Title 36, Section 670-210 Note 7 (Cumulative Annual Pocket Part 1973-1974) Revision on Abandonment - Where Commonwealth vacates a section of public highway less than two miles in length, the part so vacated does not revert to the municipality in which it is located. The adjoining landowners have a right to reclaim the land under Section 2131 of Title 36.

Title 36, Section 2131 Land to Revert to Owners - Whenever any highway, street, court or alley shall be vacated, or hath been vacated, by authority of law, the adjoining owner or owners shall be authorized to reclaim the same, to the center thereof, unless the ground was originally taken in unequal proportions from the then owners thereof, and in such cases, the adjoining owners shall reclaim, in the proportion contributed by such owners, or by those under whom they shall have derived their titles.

Title 36, Section 2131 Land to Revert to Owners - Note 2 (Cumulative Annual Pocket Part 1973-1974) Construction and Application - Where Commonwealth, under Section 670-210 (above) vacates a section of public highway less than two miles in length, the part so vacated does not revert to the municipality in which it is located.

Title 36, Section 670-214 Maintenance of Parts of Roads Abandoned as State Highways; Vacation When Not of Full Width - Where any section of a State highway route shall be, or has been relocated, the portion of the public road or highway, thus abandoned as a State highway route, shall be maintained by, and at the expense of, the township, borough, town or city wherein it is located . . .

Title 36, Section 670-215 Power of Court to Vacate Parts of Certain Highways sets forth that the Court of Quarter Sessions shall have power to inquire of, and vacate any part or parts of any former State Road . . . which has been adopted as a state highway, where such part, or parts thereof due to the change or relocation of the State Highway, no longer forms a part of such State Highway. Such vacation shall be in the same manner as in the case of the vacation of roads under general road law.

Title 36, Section 1981 Authority of Courts - The courts . . . within their respective counties have authority, upon application to them by petition, to inquire of and to change or vacate the whole or any part of any private or public road which may have been laid out by authority of law, whenever, the same shall become useless, inconvenient or burdensome notwithstanding the fact that vacation of a part of a public road results in leaving the remaining part or parts of a road with one of its termini at a point other than a public highway or place of public resort. Provided that the other terminus of each of the remaining parts of the road is in a

public road and that each remaining part of the road is necessary for public travel or for the use of a property owner or owners located on such remaining part. The said courts should proceed therein by views and reviews as provided for in laying out of public roads and highways.

Under the foregoing procedure, it appears (1) that the Water and Power Resources Board must concur as to the contract (2) the Secretary of the Highway Department abandons the road with a concurrence of the local authorities and the Governor.

PENN TOWNSHIP ROADS

Noble E. Noecker, Road Foreman for the Supervisors of Penn Township, and William Reifsnyder, life-long resident and employee of Penn Township, have submitted sworn affidavits stating that Penn Township, Berks County, Pennsylvania, has exercised ownership rights over Township Road 715 extending west from Main Street in Bernville, for at least thirty (30) years.

Township Road 715 will be raised on its existing alignment to intersect the raised Legislative Route 06017.

According to 53 Purdon's Pennsylvania Statutes Annotated 66105, there is a presumption that there was a lawful opening and dedication where the Township expended money on a road used by the traveling public for over twenty-one (21) years. Penn Township has a compensable interest in Township Road 715.

AUTHORITY OF THE TOWNSHIP (ROADS)

The township under its general powers (Title 53 Municipal and Quasi-Municipal Corporations 65701) may sue and be sued, purchase, acquire by gift or otherwise, hold, lease, let and convey by sale or lease, such real and personal property as shall be deemed to be to the best interests of the township. Each township may make contracts for lawful purposes and for the purpose of carrying into execution the provisions of this act and the laws of the Commonwealth, Title 53, Section 65801.

Reference again is made to Title 32, Forests, Waters and State Parks, Sections 678.1 and 678.2 shown on page 3 wherein the Township supervisors may contract with the United States for the relocation and/or abandonment of Township Roads and the conveyance of flowage easements.

The Township supervisors appear to have alternative methods of vacating roads. They are as follows:

(1) Title 53, Section 66101 - The supervisors may enact ordinances to lay out, open, vacate and relay all roads and parts thereof which are wholly within the Township, upon the petition of interested citizens or without petition if in the judgment of the supervisors, it is necessary, the Township officials may also by ordinance open . . . vacate and relay roads partly within the Township, wherein, similar concurrent action is taken by the authorities of all political subdivisions wherein the land is located.

Title 53, Purdon's Statutes, Section 66115 sets forth that whenever the supervisors of the Township thinks it wise to relocate any part of any public road under their supervision, or to vacate any abandoned portion of State Highway not vacated by the Department of Highways and the supervisors can agree with the property owners affected by such relocations or vacation, they may relocate or vacate without the formality of review but by petition, and a map thereto should be presented to the Court of Quarter Sessions for approval before actual relocations or vacation is made, whereupon the new location approved by the court shall be taken to be the public road and the old road shall be vacated or the abandoned State Highway shall be vacated.

Note 1 (Cumulative Annual Pocket Part 1973-1974) The effect and purpose of this section is to take out of the juris of the court the laying out, etc., of roads where the amount involved is small and the affected property owners agree, and to vest in the Township supervisors the final determination of the advisability of making the improvement. The cost to the Township must be less than $1,000.00.

BERNVILLE BOROUGH STREETS

Gerard J. Hoyer, President of Frankhouser Associates, Incorporated, and the Engineer for the Borough of Bernville, has submitted a sworn affidavit stating that the Borough of Bernville has operated and maintained the following roads falling within the boundaries of the Bernville Protective Works for a period of more than twenty-one (21) years and has a compensable interest in said roads:

(1) Washington Street - Acquired when the Borough of Bernville annexed land from Penn Township, December 14, 1950.

(2) Third Street - Acquired when the Borough of Bernville annexed land from Penn Township, December 14, 1950.

(3) Fourth Street - Acquired when the Borough of Bernville annexed land from Penn Township, December 14, 1950.

(4) Fisherman's Lane - Acquired when the Borough of Bernville annexed land from Penn Township, December 14, 1950.

(5) Fox Alley - Acquired when the Borough of Bernville annexed land from Penn Township, December 14, 1950.

According to Title 53, Section 46702 Right of Borough to Take Over Streets - Any borough shall have the right at any time to take over, by laying out and/or opening . . . any street to which the public shall have acquired rights by constant use over a period exceeding twenty-one (21) years.

The Borough of Bernville has a compensable interest in these streets.

The Design Memorandum proposes to ramp up the above borough streets to meet the raised Legislative Route 310. In addition, there are two privately owned alleys between Third Street and Fourth Street that will also be ramped up to Legislative Route 310. These alleys will not be included in a relocation contract with the borough.

AUTHORITY OF THE BOROUGH (ROADS)

Title 53, Section 46731 Authority to Open Streets; Procedure - Any borough shall have authority, by ordinance (i) to open any street or portion thereof previously laid out; or (ii) simultaneously to lay out and open any street or portion thereof. Any street or portion thereof so opened shall be a public street of the borough. No such ordinance shall become effective until thirty days after the enactment thereof. Within ten days after the enactment of any such ordinance, the borough shall give personal notice to the owners of all property abutting the street so proposed to be opened. During such thirty day period between the enactment and taking effect of such ordinance, any interested party may petition council for a hearing, which council shall hold within thirty days after the date of such petition, and of which the borough shall give at least fifteen days' notice in a newspaper of general circulation in the borough. Any such petition shall serve to stay the effective date of such ordinance, until council shall have held such hearing and shall have acted upon such petition by motion, or in case of further appeal, until the court shall have finally disposed of the matter. After such hearing and within thirty days after action by council upon such petition, any part aggrieved by council's action thereupon may appeal to the Court of Quarter Sessions.

Title 53, Section 46741 Borough Code, Ch. 91 Authority to Vacate Streets; Procedure - Any borough shall have authority, by ordinance, to vacate or close any street or portion thereof previously opened or laid out, but no street or portion thereof providing the sole means of access to any lot or tract of land shall be vacated unless those to whom access would be denied shall consent. No such ordinance shall become effective until thirty days after the enactment thereof. Within ten days after the enactment of any such ordinance, the borough shall give personal

notice to the owners of all property abutting on the street or portion thereof so proposed to be vacated. If any street or portion thereof proposed to be vacated shall be on a recorded plan, the borough shall also give personal notice of the proposed vacation thereof to all owners of property appearing on such plan. During such thirty-day period between the enactment and taking effect of such ordinance, any interested party may petition council for a hearing, which council shall hold within thirty days after the date of such petition, and of which the borough shall give at least fifteen days' notice in a newspaper of general circulation in the borough. Any such petition shall serve to stay the effective date of such ordinance, until council shall have held such hearing and shall have acted upon such petition by motion, or, in case of further appeal, until the court shall have finally disposed of the matter. After such hearing and within thirty days after action by council upon such petition, any part aggrieved by council's action thereupon may appeal to the Court of Quarter Sessions.

Title 53, Section 46744 Effect of Vacation - When a street or portion thereof shall have been vacated, all public right in or to such street or portion thereof shall cease, but such vacation shall not affect any private rights acquired by any of the owners of abutting property.

Title 53, Section 46751 Authority to Straighten and Relocate Streets; Procedure - Any borough may, by ordinance, provide for straightening and/or relocating any street previously opened, involving the opening of a portion of such straightened and/or relocated street over land not previously a portion of such street and/or the vacation of a portion of such previously opened street no longer to be used for street purposes. In such cases, such straightening and/or relocation shall be considered as an opening and/or vacation and shall be effected in the same manner and by the same procedure as provided in prior sections of this article for opening or vacation of streets, as the case may be, but such opening and/or vacation may be considered as a single proceeding, to be affected by enactment of a single ordinance, and it shall not be necessary to enact one ordinance for vacation and another for opening.

Title 53, Section 46401 Power to Make Contracts - Each borough may make contracts for lawful purposes and for the purposes of carrying into execution the provisions of this act and laws of the Commonwealth.

LEGAL OBLIGATIONS (ROADS)

The obligation of the Government in road cases is premised upon the fact that there has been a "taking". The obligation by reason of this "taking" is the cost of providing substitute roads where such substitute is necessary (State of Washington vs. U. S. (1954) 214 Fed. 2d 1933).

The substitute road would be what might reasonably be required and not necessarily be equivalent. The necessity for replacement in order to readjust the system of State, County or Township highways is dependent upon the circumstances of each case, the primary thought being the requirements of the traveling public (U. S. vs. Alderson (1954) 53 Fed. Supp. 528).

The relocation or alteration of the various Commonwealth, Township and Borough roads as herein proposed, will maintain the original traffic patterns of the area. It is the reasonable obligation of the Government to relocate and/or alter these roads at Government expense.

BERNVILLE BOROUGH SEWER LINES

FACTS

The effluent outfall from the Bernville sewage treatment plant to the Tulpehocken Creek will be rerouted and a sewage lift pump will be provided. The Borough owns the following rights of way for this line:

(1) Miscellaneous Book Volume 311, page 456, Berks County Records - Clarence W. Mengel and Lillian W. Mengel, his wife and Henry L. Kalbach and Marion B. Kalbach, his wife - agreement and right of way to Bernville Borough Authority.

(2) Miscellaneous Book Volume 311, Page 509, Berks County Records - Borough of Bernville - agreement and right of way to Bernville Borough Authority.

The only other existing sewer line affected is along Legislative Route 310. Six manholes will be raised from one to ten feet to clear the fill of Legislative Route 310.

(1) Manhole Number 43 and manhole number 52 located between Washington Street and Fourth Street are covered by an agreement and right of way given by John H. Balthaser and Irene M. Balthaser, his wife, to Bernville Borough Authority recorded in Miscellaneous Book Volume 311, Page 468, Berks County Records.

(2) Manhole number 53 located in the bed of Fourth Street is covered by an agreement and right of way given by Grace M. Stoudt and George W. Stoudt, her husband, to Bernville Borough Authority recorded in Miscellaneous Book Volume 311, page 494, Berks County Records.

(3) Manhole number 54 located between Third and Fourth Streets is covered by an agreement and right of way given by Bernville Community Fire Company to Bernville Borough Authority recorded in Miscellaneous Book Volume 311, page 484, Berks County Records.

(4) Manhole number 55 and manhole number 57 are located between the right of way lines of Legislative Route 310 at its intersection with Third Street.

The Bernville Borough has a compensable interest in its rights of way for the effluent outfall sewer as well as the six manholes.

AUTHORITY OF THE BOROUGHS

Title 53, Section 46202 Specific Powers - The powers of the borough shall be vested in the corporate authorities. Among the specific powers of the borough shall be the following, and in the exercise of any of such powers involving the enactment of any ordinance or the making of any regulation, restriction or prohibition, the borough may provide for the enforcement thereof and may prescribe penalties for the violation thereof or for the failure to conform thereto . . .

Street and Sewer Regulations; Obstruction - To regulate the streets, sewers, public squares, common grounds, sidewalks, curbs, gutters, culverts and drains, and the heights, grades, widths, slopes and construction thereof; and to prohibit the erection or construction of any building or other obstruction to the convenient use of the same.

Title 53, Section 46401 Power to Make Contracts - Each borough may make contracts for lawful purposes and for the purposes of carrying into execution the provisions of this act and laws of the Commonwealth.

LEGAL OBLIGATION OF THE UNITED STATES

In United States v. Miller (1943, 317 U. S. 369, 63 S. Ct. 276, 87 L. Ed. 336) the Supreme Court has said that "the Fifth Amendment of the Constitution provides that private property shall not be taken for public use without just compensation." The determination of "just compensation" is a judicial question. In publicly-owned roads and utility systems, as well as in privately-owned railroads and utility systems, the Federal Courts have held that the liability of the United States for such acquisition is the cost of providing substitute facilities where substitute facilities are, in fact, necessary (ER 1180-1-1, Section 73-105). Where a replacement is necessary, a substitute facility will be provided which will as nearly as practicable serve the owner in the same manner and reasonably as well as does the existing facility (Section 73-106).

METROPOLITAN EDISON COMPANY

INVESTIGATION

R. B. Heist, Secretary of Metropolitan Edison Company, submitted a sworn affidavit dated 2 October 1972, stating that:

The Company was incorporated by letters patent on the twenty-fourth day of July, 1922, in the Commonwealth of Pennsylvania, with its present principal place of business being 2800 Pottsville Pike, Muhlenberg Township, Berks County, Pennsylvania.

The Company is a subsidiary of General Public Utilities Corporation formed for the purposes of the manufacture and supply of light, heat and power by electricity.

The Company is authorized to make contracts in its corporate name for business purposes and further to hold, acquire, purchase, convey, mortgage, encumber and lease its land and facilities.

Metropolitan Edison Company has the authority to relocate its facilities under the Charter and the laws of the Commonwealth of Pennsylvania, Purdon's Pennsylvania Statutes Annotated, Title 15, Section 3001, et seq, and Title 66, Section 1101, et seq.

The Company is regulated by the following Governmental entities in accordance with the designated statutes, to wit: Pennsylvania Public Utility Commission - Pennsylvania Public Utility Code; Securities and Exchange Commission - Holding Company Act of 1935; and the Federal Power Commission - Federal Power Act.

FACTS

The facilities of the Metropolitan Edison Company which will be affected by the construction of the Bernville Protective Works are shown on plates 5 through 8. These relocations are required in order to maintain service to remaining customers in the project area.

OWNERSHIP

The Company has a compensable interest in its rights of way for its lines in the areas to be affected by the Bernville Protective Works.

TRACT NO.	GRANTOR	BERKS COUNTY MISC. BOOK/PAGE	DATE
1023-2	Annie L. Obold	162/11	4/20/49
1023-2	Heidelberg Inc.	275/185	8/14/68
	"	279/49	3/19/69
	"	279/51	3/19/69
	"	279/53	3/19/69
	"	271/271	1/ 9/68
1037	Robert Katz & Paula h/w	272/462	2/28/68
1042	Doris I. Parker	179/407	8/24/55
	"	271/1168	3/ 5/68
1043	Edna M. Burkey	144/654	2/29/44
	"	179/409	3/24/55
1044	George W. Stout & Grace M. h/w	179/411	8/ 8/55
	"	191/461	4/ 5/56
1046	R. H. Marberger	191/462	1956
	"	139/223	1940
	"	272/508	1968
1053	Clarence W. Mengel & Lillian W. h/w Henry L. Kalbach & Marion B. h/w	168/169	9/19/49

LEGAL OBLIGATION OF THE UNITED STATES

In United States v. Miller (1943, 317 U. S. 369, 63 S. Ct. 276, 87 L. Ed. 336) the Supreme Court has said that "the Fifth Amendment of the Constitution provides that private property shall not be taken for public use without just compensation." The determination of "just compensation" is a judicial question. In publicly-owned roads and utility systems, as well as in privately-owned railroads and utility systems, the Federal Courts have held that the liability of the United States for such acquisition is the cost of providing substitute facilities where substitute facilities are, in fact, necessary (ER 1180-1-1, Section 73-105). Where a replacement is necessary, a substitute facility will be provided which will as nearly as practicable serve the owner in the same manner and reasonably as well as does the existing facility (Section 73-106).

BETHEL AND MT. AETNA TELEPHONE AND TELEGRAPH COMPANY

H. R. Baldwin, Secretary of the Bethel and Mt. Aetna Telephone and Telegraph Company, submitted a sworn affidavit dated 30 December 1974, stating that:

The Company was incorporated on the 21st day of February, 1966, in the Commonwealth of Pennsylvania, with its principal place of business in the City of Erie.

The Articles of Incorporation provide that:

The Company is authorized to make contracts in its corporate name for business purposes.

The Company is authorized in its corporate name to hold, acquire, purchase, convey, mortgage, encumber and lease its land and facilities.

The Company was formed for the purpose of the furnishing of telephone and telecommunication services to the public and doing all things incidental and necessary therefor in the Counties of Berks, Dauphin, Lancaster and Lebanon; provided, however, that this corporation will not perform any acts subject to the jurisdiction of the Pennsylvania Public Utility Commission without its approval.

Bethel and Mt. Aetna Telephone and Telegraph Company has the authority to relocate its facilities under the Charter and the Laws of the Commonwealth of Pennsylvania, Purdons's Pennsylvania Statutes Annotated, Title 15, Section 3301, et seq.

The Company is regulated by the Pennsylvania Public Utility Commission in accordance with Public Utility Law, Act of May 28, 1937, Public Law 1053, Section 1, et seq.

FACTS

The facilities of the Bethel and Mt. Aetna Telephone and Telegraph Company which will be affected by the construction of the Bernville Protective Works are shown on plates 5 through 8. Relocations are required in order to maintain service to remaining customers in the project area.

OWNERSHIP

The Bethel and Mt. Aetna Telephone and Telegraph Company has been unable to locate any recorded rights of way agreements covering their rights of way in the areas affected by the Protective Works. I have personally searched the Court House records and have also been unable to locate any rights of way in these areas.

The Bethel and Mt. Aetna Telephone and Telegraph Company has no compensable interest in its rights of way affected by the Bernville Protective Works.

LEGAL OBLIGATION OF THE UNITED STATES

Where a public utility will be damaged or destroyed due to the operation of a civil works project, and relocation or alteration of the facility is required to continue service to the public, the Government may assume the cost of relocating or altering the facility (but not the cost for a new right of way) when in fact, the utility owner is not presently vested with a compensable interest in the existing right of way(Section 2, Flood Control Act of 1938, 52 Stat. 1215; 33 U. S. C. 701c-1).

HEIDELBERG INCORPORATED

The Pennsylvania Department of Environmental Resources has required Heidelberg, Incorporated to run an eight inch sewer line, which will interfere with the Bernville Protective Works. Plans for the sewer have not yet been finalized. The final design of the crossing will be coordinated with the District. Any additional costs over the cost of the crossing without the dikes will be paid as an advanced relocation. Relocation of the sewer constructed without regard to the dike would be more costly than providing for the dike in the initial sewer construction.

AUTHORITY

ER 1180-1-1, paragraph 73-209.7 Corps of Engineers Cooperation With Other Federal and Non-Federal Interests in Facilities in Civil Works Project Areas Where Projects Are Authorized But Where The Construction Funds Therefor Have Not Been Appropriated, allows for advanced relocation if:

(1) The project concerned has been authorized.

(2) There is reasonable expectation that the project will bepplaced under actual construction within the foreseeable future.

(3) The Government's share of the cost of installing the facility in a location and at an elevation that will be compatible with the Federal project, plus accumulated compound interest at the prescribed rate for the estimated period prior to Federal project construction, will be less than the cost of relocation at a later date.

CONCLUSIONS

(1) That the United States Army Engineer District, Philadelphia, may assume the cost of relocation and/or alteration to Commonwealth of Pennsylvania, Legislative Routes 310 and 06017 caused by the Bernville Protective Works.

(2) That the United States Army Engineer District, Philadelphia, may assume the cost of relocation and/or alteration to Penn Township Route 715 caused by the Bernville Protective Works.

(3) That the United States Army Engineer District, Philadelphia, may assume the cost of relocation and/or alteration to the following Bernville Borough Streets affected by the Bernville Protective Works: Washington Street, Third Street, Fourth Street, Fisherman's Lane and Fox Alley.

(4) That the United States Army Engineer District, Philadelphia, may assume the cost of relocation and/or alteration to the Bernville Borough Sewer System caused by the Bernville Protective Works.

(5) That the United States Army Engineer District, Philadelphia, may assume the cost of relocation and/or alteration to the facilities of the Metropolitan Edison Company.

(6) That the United States Army Engineer District, Philadelphia, may assume the cost of relocation and/or alteration to the facilities of the Bethel and Mt. Aetna Telephone and Telegraph Company, but not the cost for any new rights of way that may be needed.

(7) That the United States Army Engineer District, Philadelphia, may assume the costs over and above the cost to Heidelberg Incorporated of a sewer crossing without the protective works dike, as an advanced relocation.

23 December 1974
DATE

Mark Dolchin

MARK DOLCHIN
Attorney Advisor